Ailtech

Models F321A - F322A
F323A - F324A

VCH

INSTRUCTION MANUAL

MODELS F321A–F322A F323A AND F324A

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SECTION I

INTRODUCTION

GENERAL

This manual contains complete instructions for the F320A Series Data Royal Test Oscillators. Included in this series are the following:

Model F321A	Sine Wave Oscillator
Model F322A	Sine Wave Oscillator, with Expanded Meter
Model F323A	Sine/Square Oscillator
Model F324A	Sine/Square Oscillator, with Expanded Meter

DESCRIPTION

The Data Royal F320A Series are high frequency Sine or Sine/Square Generators. Each instrument provides continuously variable selection of frequency from 10Hz to 10MHz in 6 ranges and a full decade vernier control.

The Sine Wave output of all these is continuously variable from -70dBm to +20dBm by means of a precision step attenuator and a vernier within each step. (0dBm = 1mw into 50Ω). Both 50Ω and 600Ω output impedances are provided for the Sine Wave output.

In addition to the Sine Wave output, the Model F322A has an expanded output level meter. The expanded meter provides a full scale deflection for a 5% change in output level. Therefore, the output can be adjusted to a precise level as necessary in frequency response applications.

The Model F323A Sine/Square Oscillator, in addition to the Sine Wave output, provides a Square Wave at the same frequency as the Sine Wave. The Square Wave output amplitude is variable from near zero to 5 volts peak-to-peak. 50Ω and 75Ω output BNC connectors are provided.

The Model F324A has all the features mentioned above.

SECTION II

INSPECTION AND INSTALLATION

Your Data Royal Generator is ready for use immediately upon receipt. Make the following checks, however, to assure that no damage has occured during shipment.

1. Inspect the shipping container prior to acceptance from the carrier. Note any damage to the shipping container on the carrier's receipt.

2. Inspect the instrument for damage. Check for dents, scratches, broken knobs, connectors, etc.

3. Remove the top and bottom covers and inspect for broken components or hardware.

4. If damage is not apparent until after the instrument has been accepted, file a claim for concealed damage with the carrier within 15 days after receipt. All packaging material must be kept for inspection by the carrier's agent. A copy of the claim must be forwarded to Data Royal Corporation.

RACK MOUNTING:

Data Royal Generators are ready for bench operation as shipped from the factory. If specifically ordered, the necessary parts for rack mounting are packaged with the instrument. To convert to rack installation refer to Figure 2-1 and proceed as follows:

1. Remove the (4) rubber feet and the instrument bail.
2. Remove the Filler Panels from both sides.
3. Install the Rack Mounting Brackets using the #10 screws provided. The instrument is now ready to mount in a standard (19 inch) rack.

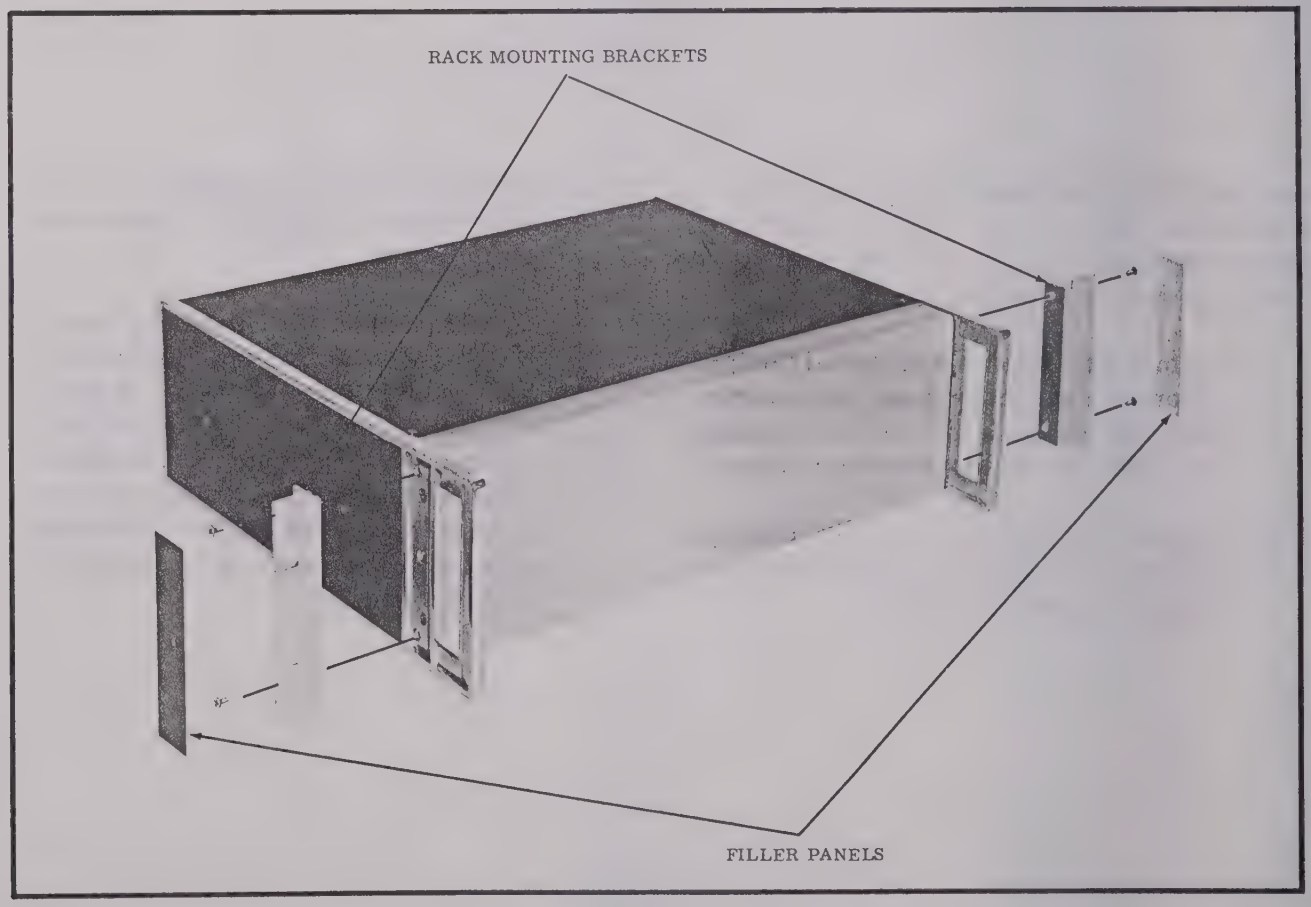


FIGURE 2-1

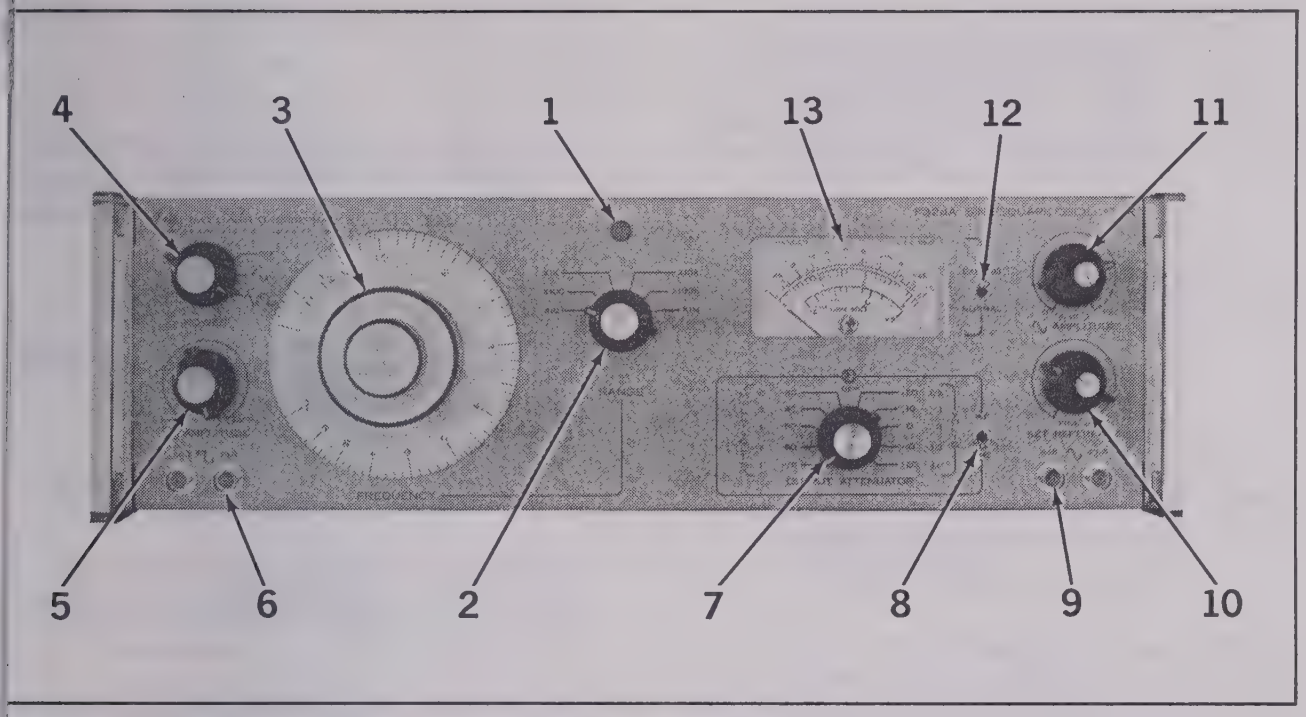


FIGURE 2-2

CONTROLS

1. Pilot Light.

2. Range Switch.
   Selects the proper RC network for the Wein bridge oscillator. Marked as multiplication factors of the dial setting.

3. Frequency Control.
   Concentric Coarse and Fine control. Varies the frequency of the oscillator between steps of the Range Switch.

4. Power Switch.
   Models F321A and F322A:
   Turns power ON or OFF.

   Models F323A and F324A:
   Applies power to the Sine Oscillator in one position, and power to both the Sine and the Square Wave circuits in the other position.

5. Square Wave amplitude control. (F323A and F324A only).

6. Square Wave. Both 50Ω and 75Ω BNC connectors provided. (F324A and F323A only).

7. Output Attenuator.
   Attenuates the Sine Wave output in 10dB steps from +20 to -70dB. Marked also in corresponding full scale voltage levels.

8. P-P/RMS Switch.
   Toggle switch selects the peak-to-peak or the rms level of the output as shown on the Output Level Meter.

9. Sine Wave output connectors.
   Both 50Ω and 600Ω BNC connectors provided.

10. Set Reference Adjust.
    Concentric Coarse and Fine controls for adjustment of precise output level, when in the Expanded Meter mode. (F322A and F324A only).

11. Sine Wave Amplitude Control.

12. EXPAND/NORMAL Switch.
    Toggle switch selects Normal or Expanded Meter readings. In the Expand position the meter indicates full scale deflection with a difference in Sine Wave amplitude of 5% from initial setting. (F322A and F324A only).

13. Output Level Meter.
    Continuously monitors the Sine Wave output level in terms of full scale, as marked on the Attenuator Switch. Also has an expanded scale graduated from -2.5% to +2.5%.

POWER REQUIREMENTS

All Data Royal instruments may be operated from either 115 or 230 volt power lines. A switch is provided on the rear panel for quick conversion. For 115 volt operation the switch must be in the UP position (115 showing). For 230 volt operation the switch must be in the DOWN position (230 showing).

CAUTION

For 230 volt operation, the line fuse must be changed to a 230 volt fuse at one half the current rating.

OPERATIONAL CHECKOUT

The operational checkout is a preliminary test and is not intended to confirm performance specifications. For complete Specification Validation Procedure see Section V.

The only test equipment required for the operational checkout is an oscilloscope capable of displaying a waveform from 10Hz to 10MHz.

To perform the operational checkout proceed as follows:

1. Position the Power Switch to OFF.

2. Insert the power cord into a 3-wire, 115/230 volt, 60-400Hz single phase power outlet.

3. Position the front panel controls as follows:

Range	X1K
Frequency Dial	1
Attenuator	+20dB
Amplitude	Mid-range
Expand/Normal Switch	Normal
PP/RMS Switch	RMS

4. Turn the Power Switch to the Sine Wave Position. Observe that the pilot light comes on at this time. (The pilot light is powered by an internal power supply).

5. Connect an oscilloscope first to the 50 ohm, and then to the 600 ohm output connectors. Observe that the frequency of the output signal is approximately 1 KHz.

6. Vary the Amplitude control from 0 to 3V. Observe that the output level varies correspondingly, as indicated on the oscilloscope. Return the Amplitude control to its 3V position.

NOTE

The 3V position indicates 3V rms output when working into a matched load. With only the oscilloscope as a load, the maximum output level is 6V rms (approximately 18V p-p).

7. Vary the Frequency dial from 1 to 10. Observe that the frequency increases correspondingly, as indicated on the oscilloscope.

8. Repeat Step 8 for each of the 5 other ranges.

9. Position the Attenuator to each step. Observe that the output level varies accordingly, as indicated on the oscilloscope. Return the Attenuator to the +20 dB position.

10. Position the PP/RMS Switch to P-P, Observe that the output level drops by approximately 9dB. Return the switch to the RMS position.

11. Position the Expand/Normal Switch to the Expand position. (F322A and F324A only.

12. Vary the Set Reference Control, and observe that the output meter indicates a level change accordingly. Return the switch to its Normal position. (F322A and F324A only).

13. Position the Power Switch to the Square Wave position. (F323A and F324A only).

14. Connect the oscilloscope first to the 50 ohm square wave output connector, and then to the 75 ohm square wave output connector. (F323A and F324A only).

15. Vary the Square Wave Amplitude control from 0 to 5V. Observe that the output level varies accordingly as indicated on the oscilloscope. (F323A and F324A only).

If the instrument fails during any portion of the operational checkout, notify your local Data Royal representative immediately. The representative will arrange the repair or replacement of your instrument at the earliest possible moment.

SECTION III

THEORY OF OPERATION

General

Before discussing the theory of operation relating to the modified Wein bridge oscillator used in the Data Royal F320A Series Sine Generators, it is appropriate to review certain fundamental considerations regarding the theory of oscillation in general.

The process of producing oscillations simply involves returning a specified portion of an amplifier's output to its input while satisfying certain conditions of phase. Different types of oscillators are classified by the means in which this is accomplished.

Figure 3-1 depicts the basic components of a feedback oscillator; an amplifier having a voltage gain of A, plus a frequency selective feedback network having a voltage gain of B.

The amplitude of the voltage appearing at the input of amplifier A is expressed by the equation

$$e_s = e_i + e_f$$

The amplitude of the voltage appearing at the output of amplifier A is expressed by the equation

$$e_o = Ae_s$$

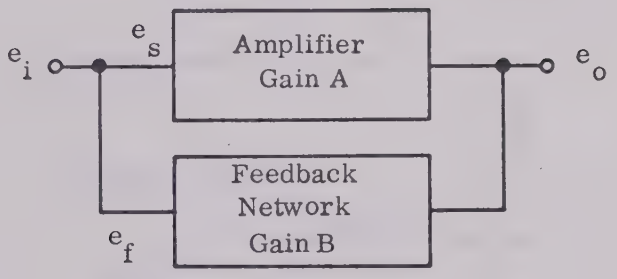


FIGURE 3-1

Considering both of the above equations it can be observed that the amplitude of the output voltage e_o is a function of the polarity and amplitude of the feedback voltage e_f. Assuming the relationship between e_i and e_f to be additive, e_o increases.

A third relationship, the transfer function of the basic circuit, is expressed by the equation

$$\frac{e_o}{e_i} = \frac{A}{1 \pm AB}$$

While a theoretical increase of the ratio e_o/e_i to infinity is inferred when the quantity $AB = -1$, it is in practice limited to a finite amount. The exact specification for oscillation is simply stated.

$$AB > 1$$

In addition to the above requirement, it is also necessary that the phase relationship between e_f and e_o be regenerative.

It is the method in which this is accomplished which determines the oscillator's classification.

Oscillator Amplifier:

The Data Royal F320A Series Sine Generators all use a modified Wein Bridge Oscillator.

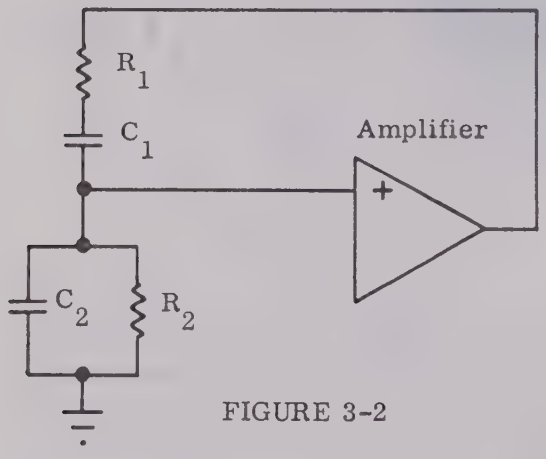


FIGURE 3-2

A basic oscillator is shown in Figure 3-2.

Oscillation occurs when the signal developed across C_2R_2 is in phase with the output signal. Since the amplifier is non-inverting (+), oscillations will occur only when a 0° phase shift exists. The frequency of oscillation is determined by capacitors C_1 C_2 and resistors R_1 R_2. The resonant frequency is obtained from the expression

$$f_r = \frac{1}{2\pi\sqrt{R_1 C_1 R_2 C_2}}$$

If the values of R_1 and R_2 are equal, and the values of C_1 and C_2 are equal, the expression is reduced to

$$f_r = \frac{1}{2\pi R_1 C_1}$$

Because the amplitude of the oscillation is a function of regenerative (positive) feedback, the output will continue to increase until some sort of limiting occurs.

In oscillators other than the Wein bridge type, this limiting occurs as the amplifier is driven to its saturation points. Restated, this means that the output is not a linear function, and is therefore, distorted.

In the Wein bridge oscillator an additional feedback network is provided to limit the output amplitude to within the linear portion of the amplifier (See Fig 3-3). This additional network is comprised of R_3 and L_1.

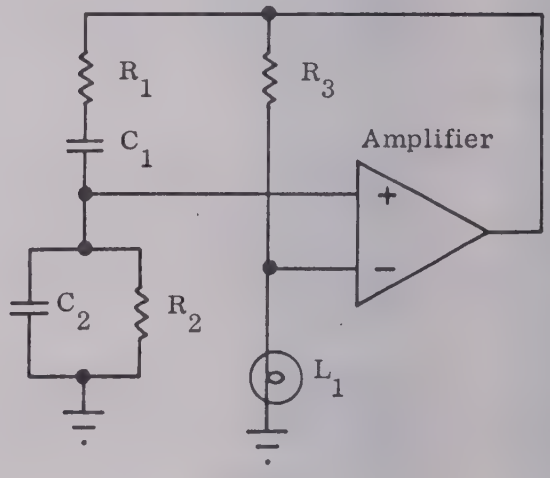


FIGURE 3-3

A lamp L_1 is used, instead of a conventional resistor, to stabilize the amplitude of the oscillations. Lamp filament resistance increases with current, tending to maintain a constant voltage at the inverting (-) input to the amplifier.

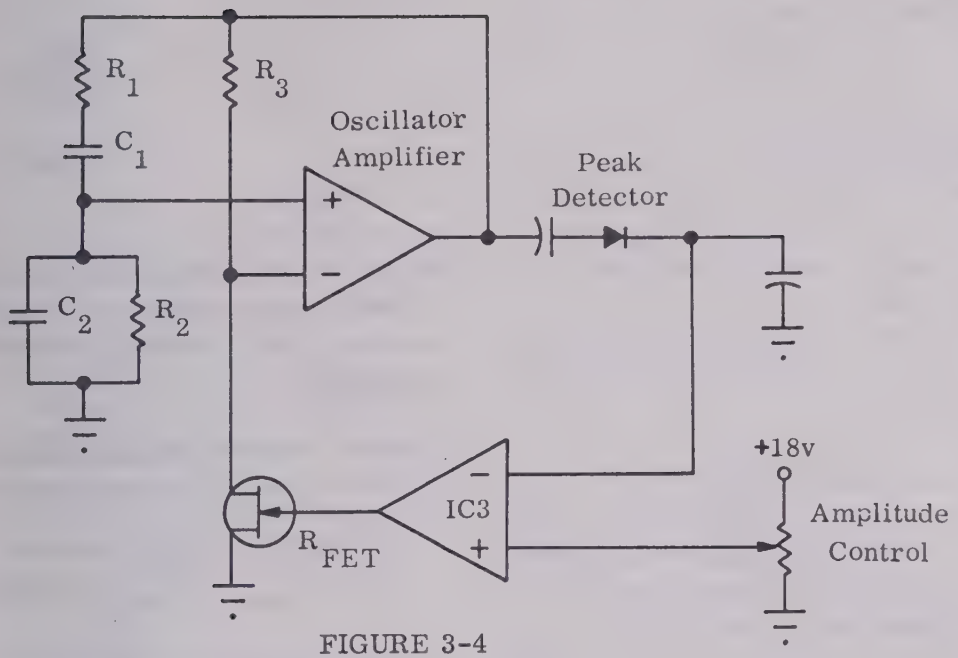


FIGURE 3-4

The voltage developed across L_1 is a function of the resistance ratio of R_3 and L_1. Because no reactive components are involved no phase shift results, regardless of frequency. The signal across L_1 is applied to the inverting (-) input of the amplifier, therefore appears degenerative, and maintains the output amplitude.

Figure 3-4 shows the modified Wein bridge oscillator, as used in the Data Royal F320A series instruments.

The FET in Figure 3-4 serves the same purpose, as did the lamp previously discussed. The output of the oscillator amplifier is rectified and applied to the inverting (-) input of I.C.3, which serves as a Control Amplifier.

The DC output of the Control Amplifier initially establishes the source-to-drain voltage (VDS) of the FET at a low value. When operating in this region the FET appears much as a variable resistor.

Any increase in oscillator output amplitude results in a proportional increase in the + DC level at the Peak Detector. This + DC is applied to the inverting (-) input of the Control Amplifier, causing its output to go more negative.

The output of the Control Amplifier is applied to the gate of the FET. A negative going DC level at the gate will tend to reduce the conductivity of the FET, effectively raising the source-drain resistance.

This, in turn, changes the ratio of R_3/R_{FET}, causing a larger proportion of the oscillator amplifier output signal to be developed across R_{FET}.

This larger signal is applied to the inverting (-) input, causing a reduction in the output signal.

It was established in the foregoing, that, in order to achieve oscillation,

$$AB > 1$$

where A = Amplifier gain,
and B = Feedback network "gain".

Consider the tuned circuit in the Wein bridge, Figure 3-5.

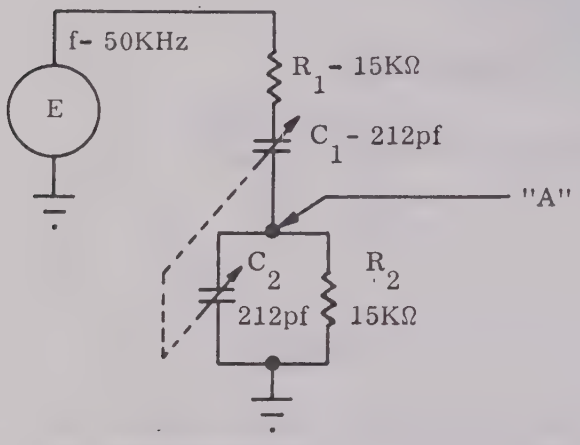


FIGURE 3-5

A few calculations reveal that the resonant frequency (f_r) of $R_1 C_1$ is the same as f_r of $R_2 C_2$, namely

$$f_r = \frac{1}{2\pi RC} = 50\text{KHz}.$$

Further, the reactance of C_1, and of C_2, equals

$$X_c = \frac{1}{2\pi fc} = 15 \text{ K ohms}$$

A standard formula for RC circuits states that

$$\text{Tan } \theta = \frac{Xc}{R}$$

In this instance

$$\text{Tan } \theta = \frac{Xc}{R} = \frac{15K}{15K} = 1$$

$$\therefore \theta = 45°$$

Inasmuch as $R_1 = R_2$, & $C_1 = C_2$, it is apparent that the phase shift across the series combination is 45° (leading), and across the parallel combination, 45° (lagging).

Another standard formula for series RC circuits states that the total impedance

$$Z_s = \frac{Xc}{\sin\theta} = \frac{15K}{.707} = 21.2\text{K ohms}$$

In parallel RC circuits, the total impedance

$$Z_p = \frac{RXc}{(R + Xc)} \cdot \frac{1}{\sin\theta} = \frac{7.5K}{.707} = 10.6\text{K ohms}$$

Re-drawing the tuned circuit with lumped impedances, (figure 3-6).

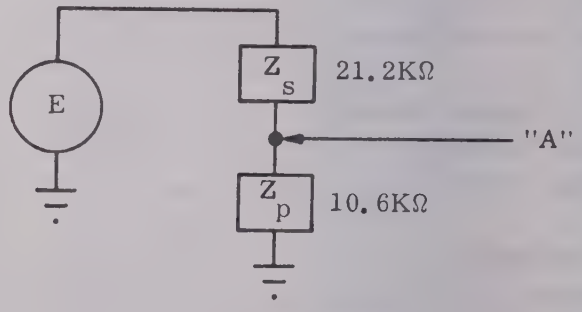


FIGURE 3-6

it will be seen that, although the net phase shift at "A" is 0 , the voltage at "A" can not exceed E/3. Effectively, then, the Feed-back network "gain" equals 1/3. Plugging this in above we get

$$(A)\ (1/3) > 1$$

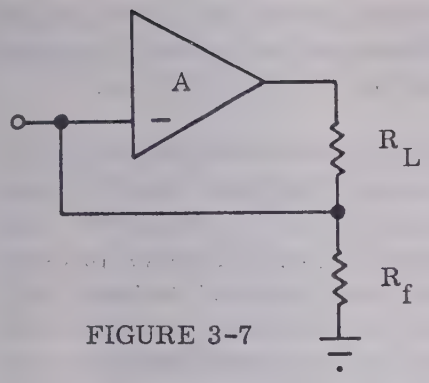


FIGURE 3-7

o satisfy this statement, it is apparent at the gain of the oscillator amplifier ust be greater than 3.

Feedback-stabilized amplifiers (fig-re 3-7), the closed-loop gain is equal to

$$\frac{R_L + R_f}{R_f}$$

Plugging in known quantities,

$$\frac{1.5K + Rfet}{Rfet} = 3,$$

and a few manipulations reveal that

$$Rfet = \frac{1.5K}{2} = 750 \text{ ohms.}$$

Thus, when R_{fet} equals 750 ohms, the gain of the oscillator amplifier is 3.

Re-drawing Figure 3-4 to correspond to the actual schematic, we get Figure 3-8, which is the oscillator amplifier. The base of Q2 corresponds to the non-inverting (+) input of a differential amplifier, and the base of Q3 corresponds to the inverting (-) input.

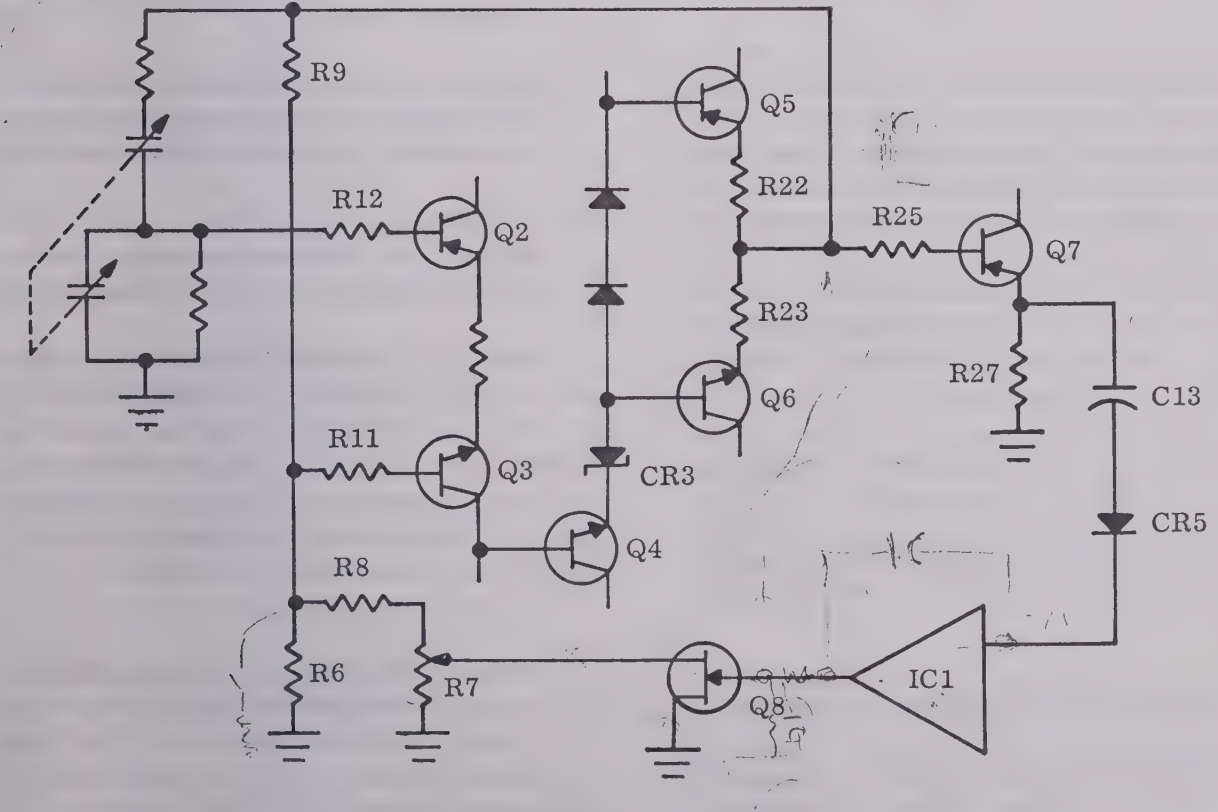


FIGURE 3-8

R_{fet} is the effective sum of R6, R7, R8 and Q8, and is controlled by the control amplifier, I.C. 1.

The output level of I.C. 1 is established by the setting of the Amplitude Control potentiometer, R39, at the non-inverting (+) input. (See Schematic #1 at the back of Section IV).

The inverting (-) input is driven by the Peak Detector, CR5 and CR13. The DC level at the (-) input is determined by the amplitude of the Oscillator Amplifier output. If the output of the oscillator increases, C13 charges through CR5, to a proportionally higher positive voltage. This positive going voltage is applied to the (-) input, causing a negative going level at the output which reduces the conductivity of FET Q8.

CR8 and CR9 serve as temperature compensation for CR4 and CR5 in the (-) input side of I.C. 1.

FET Q1 is inserted into the circuit on the X10, X100, X1K, and X10K ranges, in order to isolate the high resistance values in the tuned circuit from the relatively low input impedance of the Oscillator Amplifier.

FB1 and FB2 are Ferrite Beads, which serve to decouple the Power Supply by suppressing any parasitic oscillations, which might be present in the circuit.

The output of the oscillator amplifier is applied across the Amplitude Control Potentiometer (front panel), the arm of which is connected to the input of the Output Amplifier.

Square Wave Section: (F323A and F324A)

The Square Wave Generator is basically an amplifier, operated with positive feedback to produce limiting in the amplifier. Various refinements are added to enhance switching time (rise and fall times).

The sine wave output from the Oscillator Amplifier is coupled into the Axis Crossing Detector (Figure 3-9), which is a non-inverting amplifier. The output of this amplifier is fed directly back to its input, and, since the output is in phase with the input, the amplifier is saturated (limiting) immediately as the sine wave crosses its axis.

Symmetry is achieved by adjusting the bias point of the amplifier, so that the point, at which the sine wave crosses its axis, is coincident with the center of the linear portion of the amplifier's transfer characteristic curve (Figure 3-10).

(a) sine wave input, 0 indicates axis.

(b) correct bias adjustment (bias point = e_b). Sine wave axis is exactly coincident with e_b.

(c) incorrect bias adjustment. Bias is too far positive, thus the amplifier saturates before the sine wave crosses zero.

(d) incorrect bias adjustment. Bias is too far positive, thus the amplifier saturates after the sine wave crosses zero.

The Axis Crossing Detector is comprised of Q1 thru Q5 (See Schematic #2). Q1 is a MOS-FET working as a source follower and serves as an impedance converter to isolate the Oscillator Amplifier from the Square Wave Section, thus eliminating any loading of the Oscillator.

From the impedance converter the signal is coupled into the emitter of Q2, which is a common-base amplifier. The bias point, discussed above, is established at the base of Q2 by adjustment of R10.

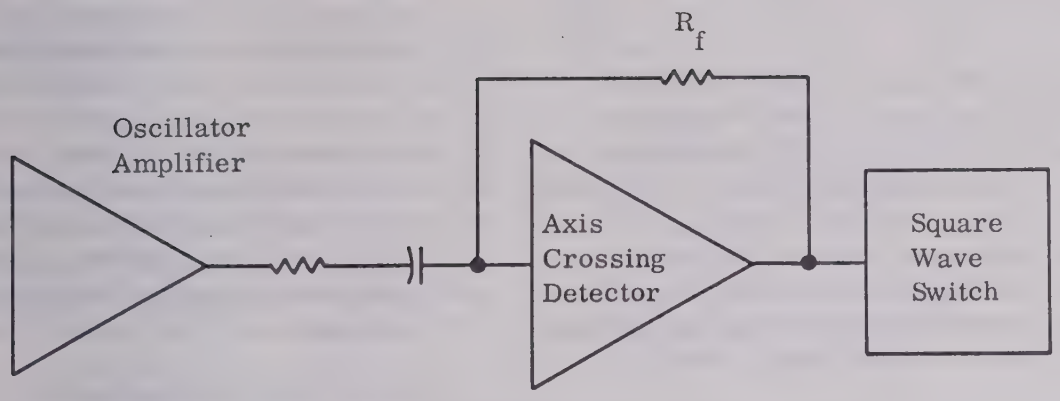


FIGURE 3-9

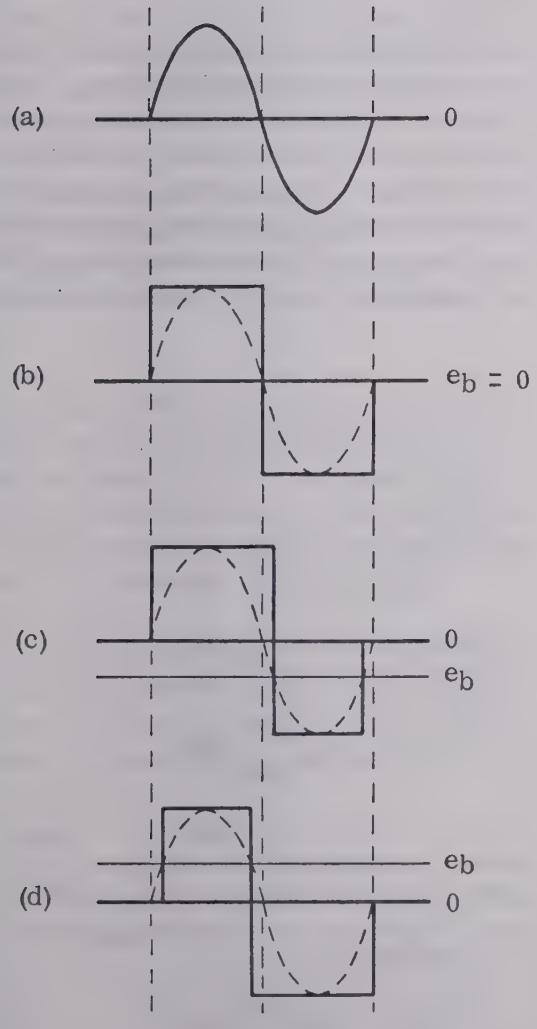


FIGURE 3-10

Q3 is an emitter-follower supplying base drive to Q4 and Q5, a pair of complementary-symmetry emitter-followers. The output of Q4 and Q5 is coupled into the square wave switch and is also taken as feedback, through R5, to the emitter of Q2.

The square wave switch consists of tunnel diodes CR5 and 6, and Q6 thru 9. The switching time of CR5 and CR6 from "low" mode to "high" mode is on the order of 0.5 nano-second. Selection of the proper operating point ensures that CR5 switches to "high" instantaneously as CR6 switches to "low". This in turn ensures that Q6 is "on" and Q7 is "off" at exactly the same time. When Q6 is on, Q8 is also on, and the collector of Q8 rises to the level of the constant plus voltage supply Q10, which is determined by the setting of R44.

Similarly, R45 controls the level of the minus voltage supply available to Q9.

The output of the square wave switch (junction of R33 and R34) is applied to the top of the Square Wave Amplitude control on the Front Panel Sub-assembly (See Schematic #2).

Output Amplifier:

The Output Amplifier is rather complex. Basically, it consists of a complementary-pair output stage, each side of which is driven by a differential amplifier.

The emitters of Q20 and Q21 are essentially at 0 volts dc. Therefore, Q20 will conduct on a positive drive signal, and Q21 will conduct on a negative drive signal.

Considering the positive portion of the amplifier (Figure 3-12), and assume a positive going signal at the input to Q3, and the base of Q2 as being grounded. Because the signal is being inverted through Q3, but not through Q2, the result is that Q16 and Q17 are being driven out of phase, but in a direction to cause them both to conduct. This results in a high impedance source for Q20, which in turn improves the linearity of Q20 and greatly reduces cross-over distortion.

The signal at the emitter of Q20 is in phase with the input signal, and is fed back to the base of Q13. Q13, therefore is being driven in two directions at once, i.e., driving the base positive tends to turn it on harder, and driving the emitter positive at the same time tends to cut it off. Thus, the output from the collector of Q13 is a function of the difference between the two driving signals.

Referring now to Schematic #3 , it will be seen that the negative portion of the Output Amplifier is identical to the positive portion.

Under a no-signal condition, Q16, 17, 18, and 19 are conducting slightly. CR15 is a "stabistor", which equals three diodes in series, all of which are matched, so their voltage drops at any given amount of current are equal, and constant over a wide range of current. The drop across CR15 is sufficient to forward-bias the output

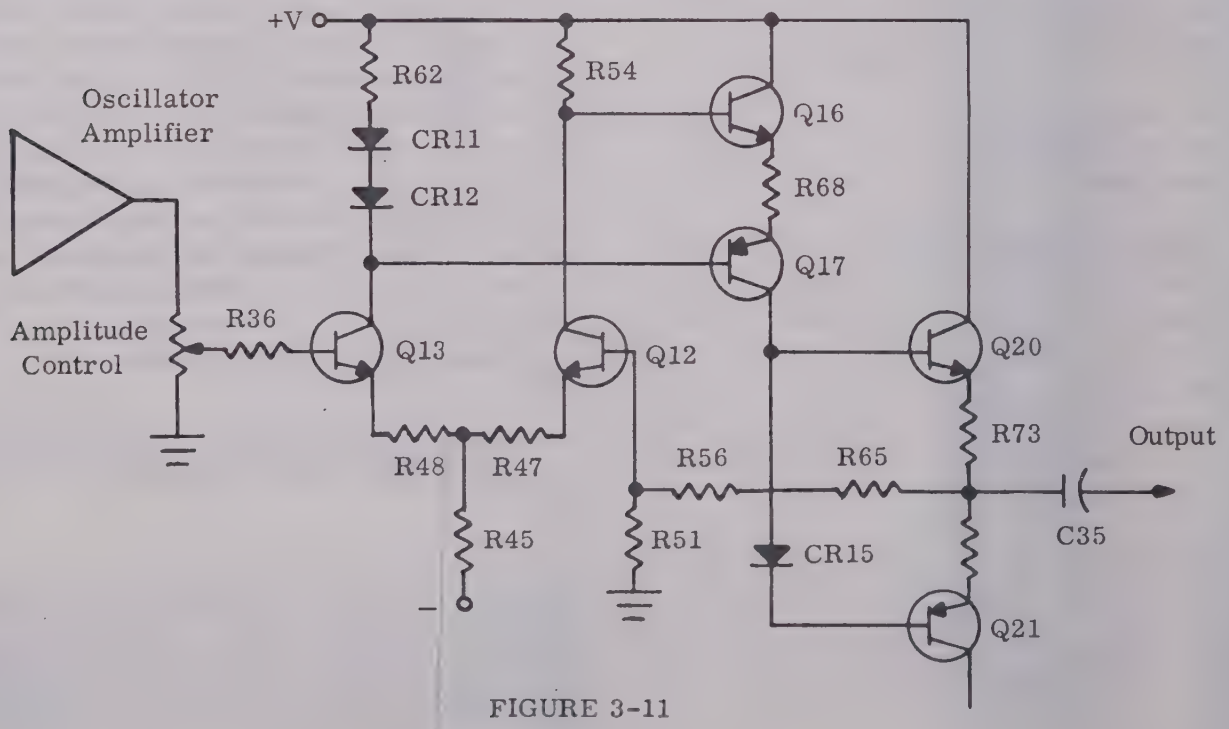


FIGURE 3-11

nsistors, Q20 and Q21. This assures duction in Q20 immediately as Q21 be- nes cut-off, thus eliminating any cross- r distortion.

The output signal is coupled through 5 to the Attenuator (front panel), and at same time applied to a feedback divider, 6, 65, and 51. The portion of the signal veloped across R51 is applied to the base Q12 as negative feedback, as discussed ove.

wer Supplies;

All the power supplies are located on same circuit board as the output ampli- r. Four different supplies are used; +25 d -25 volts, +19 and -19 volts.

All supplies are regulated, and all are ved to the +25 volt supply. The + and - supplies are identical in operation, erefore only the + supplies will be dis- ssed.

Referring to Schematic #7 , regulation the +25 volt supply is accomplished by the ssing transistor, Q2. The output voltage divided down through R23, R24 and R25 provide a variable input to the inverting input of differential amplifier, IC1.

The output voltage is also the source for , which is connected as a zener diode. breaks down at 6.7 volts and thus keeps constant voltage at the non-inverting (+) ut to IC1.

A drop in output voltage causes a less sitive voltage at the (-) input to IC1, ich results in a more positive voltage at e output (pin 6) of IC1. This voltage is plied to the gate of FET Q3, causing it conduct more, which pulls the base of negative. This results in increased nduction through Q2, which raises the output. CR5 and CR6 establish the necessary + and - supplies for the integrated circuits, IC1 and IC2.

The +25 volt supply is used as the supply for the +19 volt supply. CR9 is a 20 volt zener, which holds the base of Q9 at a constant voltage. Q9 acts as an emitter follower to supply base current to Q8, which also acts as an emitter follower, capable of supplying the current for the circuits driven by the 19 volt supply.

Output Level Meter Circuit:

The meter circuit is essentially a linear, wide-band AC amplifier, the output of which is rectified and applied to a voltmeter.

Schematic #4 shows the complete meter circuit. The Sine Wave from the Output Amplifier is fed into the base of Q3, which is an emitter follower. Q3 in turn drives Q2, which can be considered as a common-base amplifier for the input signal.

Q2 is a current source for Q2 and Q3, therefore, the input to the rectifier is a very high impedance source, greatly improving the linearity of the Level Meter. Q4 provides a high impedance feedback path for stabilization of the amplifier.

CR1 and CR2 act as temperature compensation diodes for the emitter-base junctions of Q2 and Q3. CR3, likewise, compensates for the emitter-base junction of Q1.

Expanded Meter Circuit:
(F322A and F324A).

The expanded meter circuit consists of two separate circuits, a Reference Voltage Supply and a Comparator-amplifier to drive the meter, when the EXPAND mode is

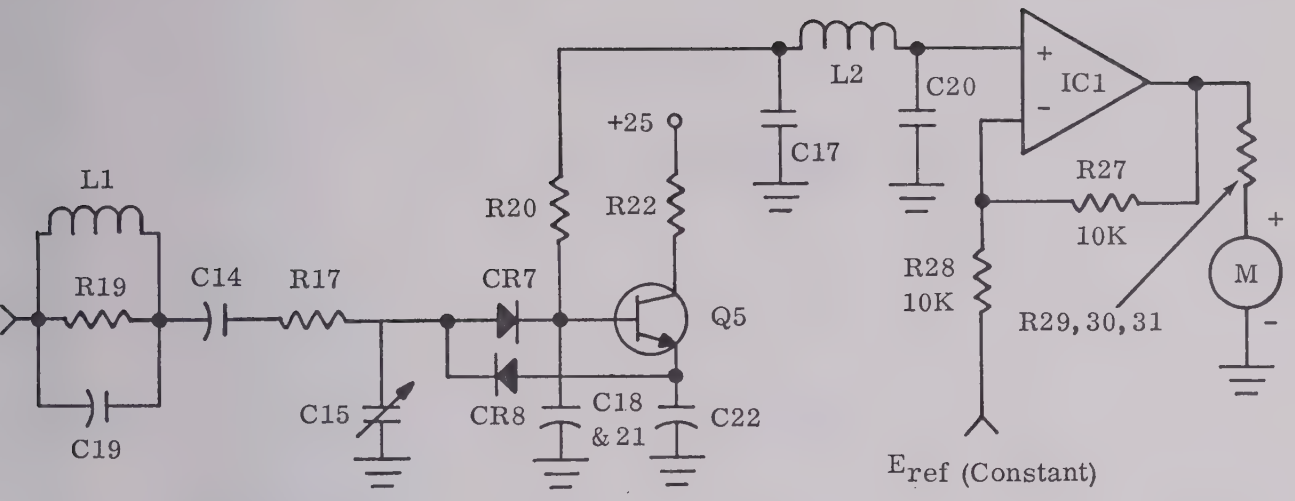

L1
R19
C19
C14
R17
C15
CR7
CR8
R20
+25
R22
Q5
C18
& 21
C22
L2
C17
C20
IC1
R27
10K
R28
10K
R29, 30, 31
M
Eref (Constant)

FIGURE 3-13

SECTION IV

MAINTENANCE

General:

This section contains information relative to preventive and corrective maintenance. The portion dealing with corrective maintenance contains trouble-shooting and corrective procedures.

Parts identification is provided on photographs of each circuit board or sub-assembly. Each photograph is on the page facing the schematic of the assembly in question.

A complete parts list for each assembly is contained on the page(s) immediately preceding each photograph.

The majority of electronic parts used in this instrument are standard, commercial parts, and replacement parts may be obtained locally. Precision components and mechanical parts, however, should be obtained through Data Royal Corporation's representative in your area.

Preventive Maintenance:

In general, no preventive maintenance, as such, is required. Occasional cleaning is recommended, and can be accomplished in conjunction with routine calibration.

A calibration cycle of six months is suggested for areas of normal operating conditions.

Re-calibration is necessary because the calibration of any instrument changes slightly with age, use and operating conditions. Also, problems which may not be apparent during normal use will show up during a calibration check. See Section III for complete calibration procedure.

Corrective Maintenance:

Table 5-1 lists the normal voltages measured at the active components.

TABLE 5-1

1. Oscillator

	Source	Drain	Gate
Q1	- 0.4	+12.5	0
Q8	0	COM	- 2.8

	2	3	4	6	7
I.C.1	+2.0	+1.95	-17.0	-3.1	+17.0

	Emitter	Base	Collector
Q2	+ 1.1	+ 0.8	-12.5
Q3	+ 1.2	+ 2.0	+10.0
Q4	+ 9.0	+ 9.5	+18.0
Q5	+ 2.1	+ 1.5	-17.5
Q6	+ 2.3	+ 2.9	+17.5
Q7	+ 2.8	+ 2.1	-17.5

2. Square Wave

	Emitter	Base	Collector
Q2	- 0.4	0	- 9.4
Q3	- 9.0	- 9.4	-17.0
Q4	- 3.2	- 3.3	+ 8.9
Q5	- 5.5	- 4.7	-12.0
Q6	COM	+ 0.7	+ 3.2
Q7	COM	- 0.7	- 3.1
Q8	- 5.9	+ 5.8	- 0.1
Q9	- 5.8	- 5.9	+ 0.2
Q10	- 5.9	+ 6.1	+17.0
Q11	- 5.8	- 6.1	-16.5

	Source	Drain	Gate
Q1	+ 0.4	+16.5	0

All readings taken with Triplett Model 630-NA, and are referenced to T. P. 2 (black) on rear panel. Range X1K; Amplitude CW.

Output Amplifier

	Emitter	Base	Collector
Q12	- 0.6	0	+18.5
Q13	- 0.6	0	+18.5
Q14	+ 0.6	0	-18.5
Q15	+ 0.6	0	-17.0
Q16	+18.5	+18.5	+24.5
Q17	+18.0	+18.5	+ 1.7
Q18	-18.0	-18.5	- .26
Q19	-18.0	-18.5	-24.5
Q20	+ 1.8	- 1.7	+23.0
Q21	+ 0.4	- .26	-23.0

. Power Supply

	Emitter	Base	Collector
Q1	+32.5	+32.5	+31.5
Q2	+32.5	+31.5	+25.00
Q5	-33.0	-32.7	-32.0
Q6	-32.7	-32.0	-25.00
Q7	COM	N.C.	+ 7.0
Q8	+19.5	+20.0	+24.0
Q9	+20.0	+20.6	+24.5
Q10	-19.5	-20.0	-24.0
Q11	-20.0	-20.5	-24.5

4. Meter Circuit

The gate of Q4 is at +10 volts as shown on Schematic #4. All other voltages track the amplitude and/or set reference controls on the front panel.

	Source	Drain	Gate
Q3	COM	+26.5	- 2.0
Q4	COM	-27.5	- 4.0

	2	3	4	6	7
I.C.1	+7.0	+6.9	-14.0	-1.1	+13.8
I.C.2	0	0	-14.0	+4.5	+13.8

PARTS LIST

DATA ROYAL ASSEMBLY: OSCILLATOR BOARD — DATA ROYAL PART NO. 29-90081-1

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITORS						
C1	1500µf	ELCTLT	6V	84171	CME-B1500	21-57219-0
C2	30pf	MICA	500V 5%	04062	DM-15-300J	21-57638-0
C3	20pf	MICA	500V 5%	04062	DM-15-200J	21-57614-0
C4	9-35pf	CER VAR		72982	538-002-940	21-63200-0
C5	1500µf	ELCTLT	6V	84171	CME-B1500	21-57219-0
C6	2-8pf	CER VAR		72982	538-00289A	21-63201-0
C7	0.01µf	CER DISC	100V	56289	TGS10	21-57001-0
C8	SELECTED					
C9	10µf	ELCTLT	25V	56289	TE-1204	21-57202-0
C10	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
C11	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
C12	10µf	ELCTLT	25V	56289	TE-1204	21-57202-0
C13	10µf	ELCTLT	25V	56289	TE-1204	21-57202-0
C14	2µf	ELCTLT	25V	56289	TE-1204	21-57209-0
C15	0.22µf	MYLAR	100V 10%	14655	WMF1P22	21-57417-0
C16	0.01µf	CER DISC	100V	56289	TGS10	21-57001-0
C17	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
C18	470pf	MICA	500V 5%	84171	DM15-471J	21-57639-0
C19	0.22µf	MYLAR	100V10%	14655	WMF1P22	21-57417-0
C20	0.01µf	CER DISC	100V	56289	TG-S10	21-57001-0
C21	0.01µf	CER DISC	100V	56289	TG-S10	21-57001-0
C22	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
C23	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
RESISTORS						
R1	820Ω	CMPSN	1/4W 5%	01121	CB8215	27-39272-0
R2	1KΩ	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
R3	22Ω	CMPSN	1/4W 5%	01121	CB2205	27-39253-0
R4	1KΩ	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
R5	3.3KΩ	CMPSN	1/4W 5%	01121	CB3325	27-39280-0
R6	1.6KΩ	CMPSN	1/4W 5%	01121	CB1625	27-39319-0
R7	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R8	360Ω	CMPSN	1/4W 5%	01121	CB3615	27-39313-0
R9	1.5KΩ	FILM	1/4W 1%	07115	NA60-1501F	27-42854-0
R10	1.2Ω	CMPSN	1/2W 5%	01121	EB12G5	27-39500-0
R11	360Ω	CMPSN	1/4W 5%	01121	CB3615	27-39313-0
R12	470Ω	CMPSN	1/4W 5%	01121	CB4715	27-39269-0
R13	2Ω	CMPSN	1/2W 5%	01121	EB20G5	27-39501-0
R14	2Ω	CMPSN	1/2W 5%	01121	EB20G5	27-39501-0
R15	560Ω	CMPSN	1/4W 5%	01121	CB5615	27-39270-0
R16	100Ω	CMPSN	1/4W 5%	01121	CB1015	27-39261-0
R17	SELECTED					
R18	2KΩ	CMPSN	1/4W 5%	01121	CB2025	27-39277-0
R19	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
R20	2Ω	CMPSN	1/4W 5%	01121	CB0205	27-39318-0
R21	120Ω	CMPSN	1/4W 5%	01121	CB1215	27-39262-0
R22	22Ω	CMPSN	1/4W 5%	01121	CB2205	27-39253-0
R23	22Ω	CMPSN	1/4W 5%	01121	CB2205	27-39253-0
R24	120Ω	CMPSN	1/4W 5%	01121	CB1215	27-39262-0
R25	1KΩ	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
R26	120Ω	CMPSN	1/4W 5%	01121	CB1215	27-39262-0
R27	5.6KΩ	CMPSN	1/4W 5%	01121	CB5625	27-39283-0

PARTS LIST

DATA ROYAL ASSEMBLY: OSCILLATOR BOARD — DATA ROYAL PART NO. 29-90081-1

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTORS (Continued)						
R28	1KΩ	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
R29	100Ω	CMPSN	1/4W 5%	01121	CB1015	27-39261-0
R30	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
R31	1KΩ	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
R32	51Ω	CMPSN	1/4W 5%	01121	CB5105	27-39258-0
R33	330KΩ	CMPSN	1/4W 5%	01121	CB3345	27-39296-0
R34	470Ω	CMPSN	1/4W 5%	01121	CB4715	27-39269-0
R35	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
R36	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
R37	470Ω	CMPSN	1/4W 5%	01121	CB4715	27-39269-0
R38	5.6KΩ	CMPSN	1/4W 5%	01121	CB5625	27-39283-0
R39	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R40	3.3KΩ	CMPSN	1/4W 5%	01121	CB3325	27-49280-0
SEMICONDUCTORS						
CR1				JEDEC	1N914	27-95001-0
CR2				JEDEC	1N914	27-95001-0
CR3				JEDEC	1N5234	27-95251-0
CR4				JEDEC	1N914	27-95001-0
CR5				JEDEC	1N914	27-95001-0
CR6				JEDEC	1N914	27-95001-0
CR7				JEDEC	1N5234	27-95251-0
CR8				JEDEC	1N914	27-95001-0
CR9				JEDEC	1N914	27-95001-0
CR10				JEDEC	1N5234	27-95251-0
CR11				JEDEC	1N5234	27-95251-0
TRANSISTORS						
Q1		40468		49671		29-04516-0
Q2		MP56519		04713		29-04539-0
Q3		2N5179		49671		29-04512-0
Q4		MPS6515		04713		29-04538-0
Q5		MPS6519		04713		29-04539-0
Q6		MPS6515		04713		29-04538-0
Q7		MPS6519		04713		29-04539-0
Q8		VCR2N		17856		29-04517-0
INTEGRATED CIRCUIT						
I.C. 1		μA709C		28584		25-08700-0

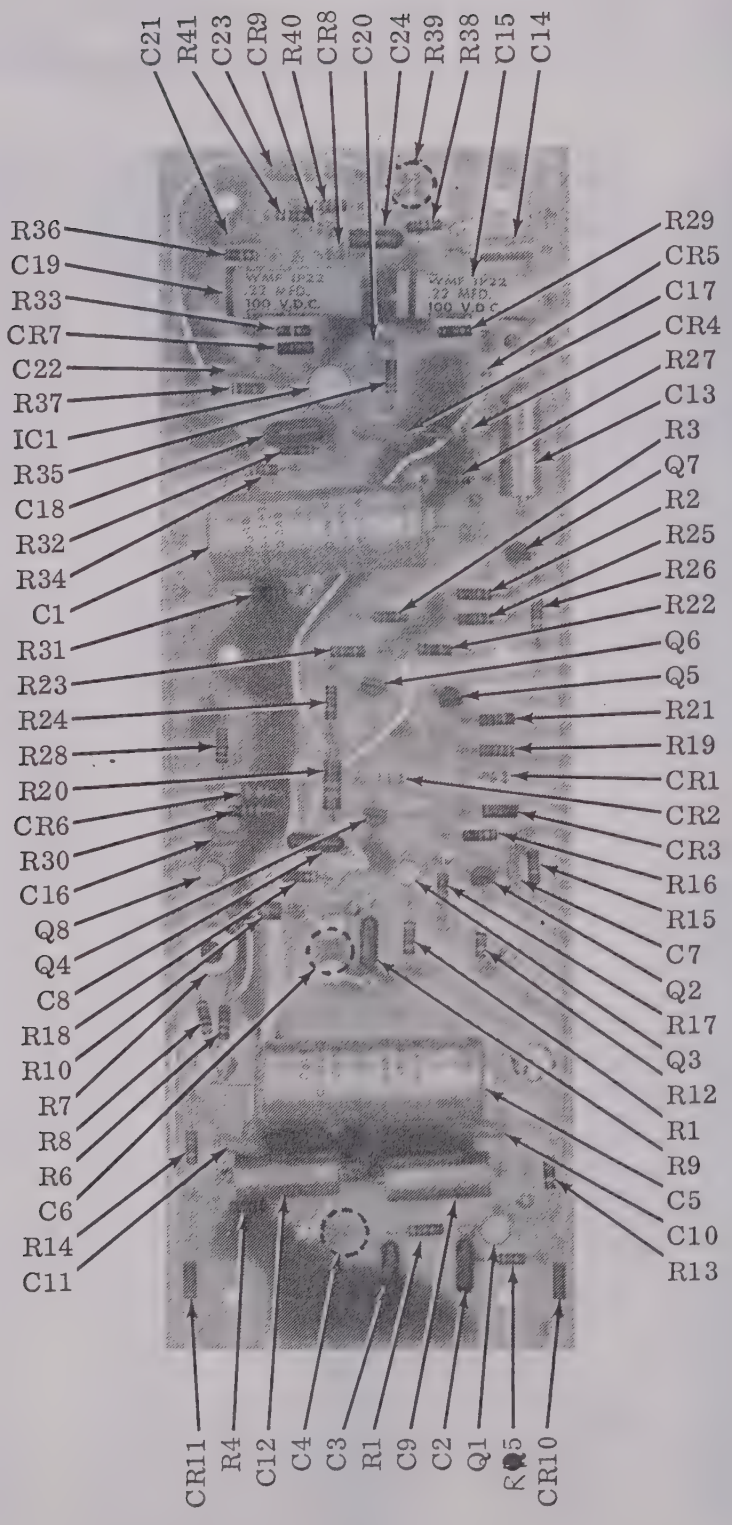
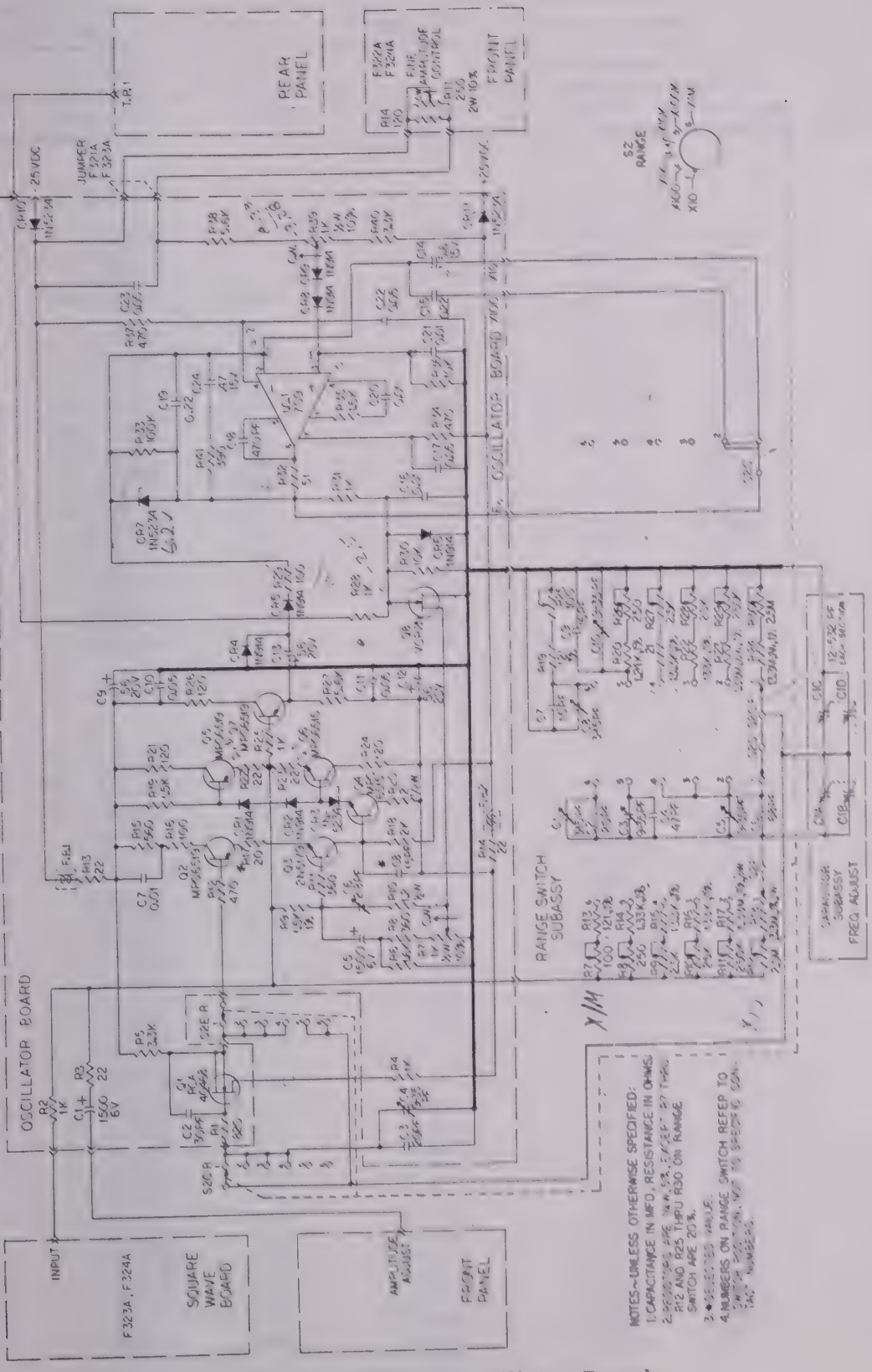


FIGURE 4-1 Oscillator Board Assembly


OSCILLATOR BOARD
RANGE SWITCH SUBASSY
REAR PANEL
FRONT PANEL
SQUARE WAVE BOARD
INPUT
F323A, F324A
AMPLITUDE ADJUST
FREQ. ADJUST
S2 RANGE
NOTES-UNLESS OTHERWISE SPECIFIED:
1. CAPACITANCE IN MFD, RESISTANCE IN OHMS
2. RESISTORS ARE ¼W, 5%, EXCEPT R7 THRU R12 AND R25 THRU R30 ON RANGE SWITCH ARE 20%.
3. * SELECTED VALUE.
4. NUMBERS ON RANGE SWITCH REFER TO SWITCH POSITION, NOT TO SPECIFIC COMPONENT NUMBERS.

SCHEMATIC #1 Oscillator Board

PARTS LIST

DATA ROYAL ASSEMBLY: F322A & F324A SQUARE WAVE BOARD — DATA ROYAL PART NO.

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITORS						
C1	.0µf	ELCTLT	25V	56289	TE-1204	21-57202-0
C2	10µf	TANT	20V	*	K10C20K	21-57800-1
C3	10µf	TANT	20V	*	K10C20K	21-57800-1
C4	39pf	MICA	500V 5%	04062	DM-15-390J	21-57616-0
C5	SELECTED					
C6	20µf	ELCTLT	15V	56289	TE-1157	21-57216-0
C7	300µf	ELCTLT	6V	56289	TE-1106	21-57207-0
C8	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
C9	10pf	MICA	500V	04062	DM-15-100J	21-57613-0
C10	20pf	MICA	500V	04062	DM-15-200J	21-57614-0
C11	27pf	MICA	500V 5%	04062	DM-15-270J	21-57637-0
C12	20pf	MICA	500V	04062	DM-15-200J	21-57614-0
C13	10pf	MICA	500V	04062	DM-15-100J	21-57613-0
C14	20pf	MICA	500V	04062	DM-15-200J	21-57614-0
C15	0.22µf	MYLAR	100V	14655	WMP1P22	21-57417-0
C16	0.22µf	MYLAR	100V	14655	WMP1P22	21-57417-0
C17	200µf	ELCTLT	15V	56289	TE1164	21-57201-0
C18	200µf	ELCTLT	15V	56289	TE1164	21-57201-0
C19	10µf	TANT	20V	*	K10C20K	21-57800-1
C20	10µf	TANT	20V	*	K10C20K	21-57800-1
RESISTORS						
R1	100Ω	CMPSN	1/4W 5%	01121	CB1015	27-39261-0
R2	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
R3	390Ω	CMPSN	1/4W 5%	01121	CB1035	27-39268-0
R4	33Ω	CMPSN	1/4W 5%	01121	CB3305	27-39255-0
R5	680Ω	CMPSN	1/4W 5%	01121	CB6815	27-39271-0
R6	390Ω	CMPSN	1/4W 5%	01121	CB3915	27-39268-0
R7	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
R8	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
R9	3.9KΩ	CMPSN	1/4W 5%	01121	CB3925	27-39281-0
R10	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R11	3.9KΩ	CMPSN	1/4W 5%	01121	CB3925	27-39281-0
R12	1.8KΩ	CMPSN	1/4W 5%	01121	CB1825	27-39276-0
R13	39Ω	CMPSN	1/4W 5%	01121	CB3905	27-39256-0
R14	820Ω	CMPSN	1/4W 5%	01121	CB8215	27-39272-0
R15	51Ω	CMPSN	1/4W 5%	01121	CB5105	27-39258-0
R16	51Ω	CMPSN	1/4W 5%	01121	CB5105	27-39258-0
R17	680Ω	CMPSN	1/4W 5%	01121	CB6815	27-39271-0
R18	68Ω	CMPSN	1/4W 5%	01121	CB6805	27-39259-0
R19	68Ω	CMPSN	1/4W 5%	01121	CB6805	27-39259-0
R20	1.8KΩ	CMPSN	1/4W 5%	01121	CB1825	27-39276-0
R21	1.8KΩ	CMPSN	1/4W 5%	01121	CB1825	27-39276-0
R22	22Ω	CMPSN	1/4W 5%	01121	CB2205	27-39253-0
R23	22Ω	CMPSN	1/4W 5%	01121	CB2205	27-39253-0
R24	820Ω	CMPSN	1/4W 5%	01121	CB8215	27-39272-0
R25	820Ω	CMPSN	1/4W 5%	01121	CB8215	27-39272-0
R26	1.8KΩ	CMPSN	1/4W 5%	01121	CB1825	27-39276-0
R27	360Ω	CMPSN	1/4W 5%	01121	CB3615	27-39313-0
R28	360Ω	CMPSN	1/4W 5%	01121	CB3615	27-39313-0

PARTS LIST

ATA ROYAL ASSEMBLY: F322A & F324A SQUARE WAVE BOARD — DATA ROYAL PART NO.

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
RESISTORS (Continued)						
R29	1.8KΩ	CMPSN	1/4W 5%	01121	CB1825	27-39276-0
R30	56Ω	CMPSN	1/4W 5%	01121	CB5605	27-39302-0
R31	56Ω	CMPSN	1/4W 5%	01121	CB5605	27-39302-0
R32	56Ω	CMPSN	1/4W 5%	01121	CB5605	27-39302-0
R33	20Ω	CMPSN	1/2W 5%	01121	EB-2005	27-39521-0
R34	20Ω	CMPSN	1/2W 5%	01121	EB-2005	27-39521-0
R35	2Ω	CMPSN	1/2W 5%	01121	EB20G5	27-39501-0
R36	2Ω	CMPSN	1/2W 5%	01121	EB20G5	27-39501-0
R37	1Ω	CMPSN	1/2W 5%	78488	EB10G5	27-39516-0
R38	1Ω	CMPSN	1/2W 5%	78488	EB10G5	27-39516-0
R39	2KΩ	CMPSN	1/4W 5%	78488	CB2025	27-39277-0
R40	100Ω	CMPSN	1/2W 5%	78488	CB1015	27-39513-0
R41	100Ω	CMPSN	1/2W 5%	78488	CB1015	27-39513-0
R42	3.9KΩ	CMPSN	1/4W 5%	01121	CB3925	27-39281-0
R43	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
R44	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R45	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R46	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
R47	3.9KΩ	CMPSN	1/4W 5%	01121	CB3925	27-39281-0
R48	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R49	27Ω	CMPSN	1/2W 5%	01121	EB2.705	27-39522-0
R50	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
SEMICONDUCTORS						
CR1		DIODE		JEDEC	1N914	27-95001-0
CR2		ZENER DIODE		JEDEC	1N5234	27-95251-0
CR3		DIODE		JEDEC	1N914	27-95001-0
CR4		DIODE		JEDEC	1N914	27-95001-0
CR5		DIODE		JEDEC	1N3719	27-95003-0
CR6		DIODE		JEDEC	1N3719	27-95003-0
CR7				JEDEC	MS7000	27-95254-0
CR8				JEDEC	MS7000	27-95254-0
CR9		DIODE		JEDEC	1N914	27-95001-0
CR10		DIODE		JEDEC	1N914	27-95001-0
TRANSISTORS						
Q1					40468	29-04517-0
Q2					MPS6519	29-04539-0
Q3				JEDEC	2N3640	29-04504-0
Q4				JEDEC	2N4274	29-04508-0
Q5				JEDEC	2N3640	29-04504-0
Q6				JEDEC	2N4274	29-04508-0
Q7				JEDEC	2N4258	29-04507-0
Q8				JEDEC	2N4258	29-04507-0
Q9				JEDEC	2N4274	29-04508-0
Q10				JEDEC	2N2218	29-04500-0
Q11				JEDEC	2N4890	29-04524-0

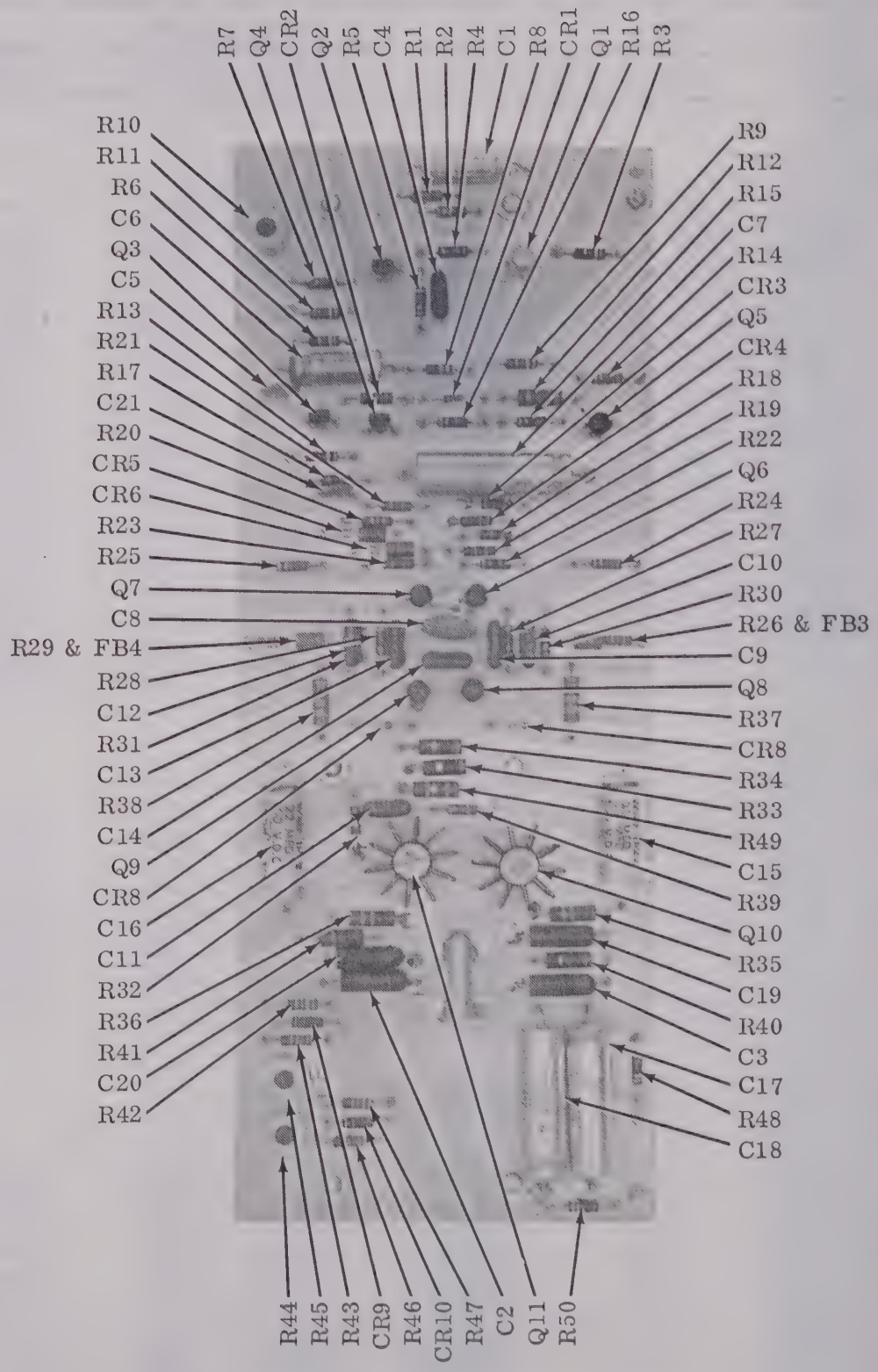
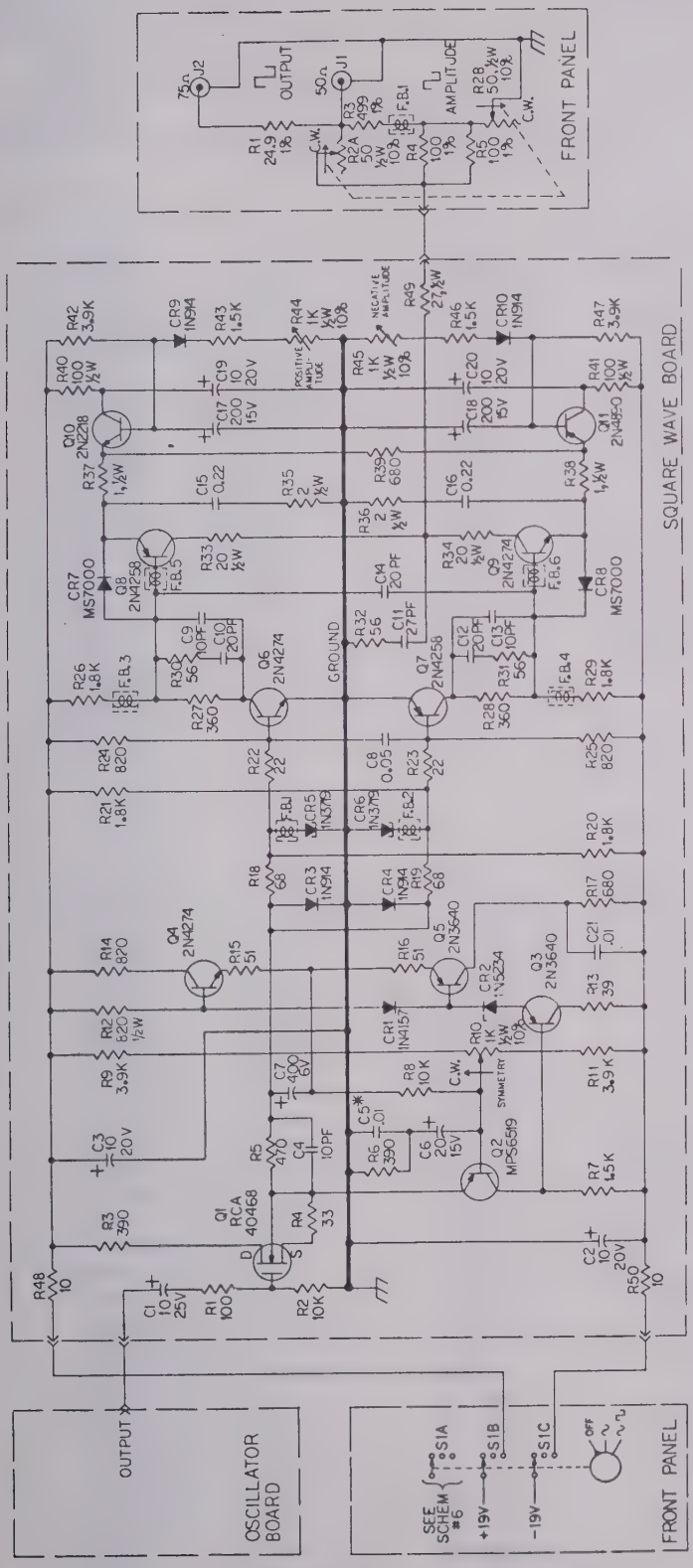


FIGURE 4-2 Square Wave Board Assembly



NOTES~UNLESS OTHERWISE SPECIFIED
1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE ¼W, ±5%.
3. * SELECTED VALUE.

SCHEMATIC #2 Square Wave Board

PARTS LIST

DATA ROYAL ASSEMBLY: OUTPUT AMPLIFIER — DATA ROYAL PART NO. 29-90080-1

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITORS						
C16	50μf	ELCTLT	50V	56289	TE1307	21-57223-0
C17	0.01μf	CER DISC	100V	56289	TG-S10	21-57001-0
C18	0.01μf	CER DISC	100V	56289	TG-S10	21-57001-0
C19	0.01μf	CER DISC	100V	56289	TG-S10	21-57001-0
C20	0.001μf	CER DISC	1000V	71590	DD-102	21-57021-0
C21	0.001μf	CER DISC	1000V	71590	DD-102	21-57021-0
C22	2-8pf	CER VAR		72982	538-002-89A	21-63201-0
C23	SELECTED					
C24	0.01μf	CER DISC	100V	56289	TG-S10	21-57001-0
C25	0.01μf	CER DISC	100V	56289	TG-S10	21-57001-0
C26	10pf	MICA	500V	04062	DM-15100J	21-57613-0
C27	0.01μf	CER DISC	100V	56289	TG-S10	21-57001-0
C28	200μf	ELCTLT	25V	56289	TE-1213	21-57206-0
C29	200μf	ELCTLT	25V	56289	TE-1213	21-57206-0
C30	50μf	ELCTLT	50V	56289	TE-1307	21-57223-0
C31	50μf	ELCTLT	50V	56289	TE-1307	21-57223-0
C32	0.01μf	CER DISC	100V	56289	TG-S10	21-57001-0
C33	0.01μf	CER DISC	100V	56289	TG-S10	21-57001-0
C34	10pf	MICA	500V	04062	DM-15-100J	21-57613-0
C35	2000μf	ELCTLT	6V	56289	39D208G0065J4	21-57208-0
RESISTORS						
R36	499Ω	FILM	1/4W 1%	12126	M1/4-499	27-42821-0
R37	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R38	330Ω	CMPSN	1/4W 5%	01121	CB3315	27-39267-0
R39	330Ω	CMPSN	1/4W 5%	01121	CB3315	27-39267-0
R40	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R41	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R42	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R43	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R44	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R45	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
R46	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
R47	20Ω	CMPSN	1/4W 5%	01121	CB2005	27-39308-0
R48	20Ω	CMPSN	1/4W 5%	01121	CB2005	27-39308-0
R49	20Ω	CMPSN	1/4W 5%	01121	CB2005	27-39308-0
R50	20Ω	CMPSN	1/4W 5%	01121	CB2005	27-39308-0
R51	100Ω	FILM	1/4W 1%	07115	NA60-1000F	27-42784-0
R52	22Ω	CMPSN	1/4W 5%	01121	CB2205	27-39253-0
R53	22Ω	CMPSN	1/4W 5%	01121	CB2205	27-39253-0
R54	680Ω	CMPSN	1/4W 5%	01121	CB6815	27-39271-0
R55	220Ω	CMPSN	1/4W 5%	01121	CB2215	27-39265-0
R56	402Ω	FILM	1/4W 1%	12126	M1/4-402	27-42813-0
R57	220Ω	CMPSN	1/4W 5%	01121	CB2215	27-39265-0
R58	680Ω	CMPSN	1/4W 5%	01121	CB6815	27-39271-0
R59	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
R60	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
R61	47Ω	CMPSN	1/4W 5%	01121	CB4705	27-39257-0
R62	1.2KΩ	CMPSN	1/4W 5%	01121	CB1225	27-39274-0
R63	1.2KΩ	CMPSN	1/4W 5%	01121	CB1225	27-39274-0
R64	47Ω	CMPSN	1/4W 5%	01121	CB4705	27-39257-0

PARTS LIST

DATA ROYAL ASSEMBLY: OUTPUT AMPLIFIER — DATA ROYAL PART NO. 29-90080-1

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	DESCRIPTION TYPE	DESCRIPTION RATING	MANUFACTURER CODE	MANUFACTURER PART NO.	DATA ROYAL PART NO.
RESISTORS (Continued)						
R65	100Ω	FILM	1/4W 1%	07115	NA60-1000F	27-42784-0
R66	100Ω	CMPSN	1/4W 5%	01121	CB1015	27-39261-0
R67	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R68	68Ω	CMPSN	1/2W 5%	01121	EB6805	27-39524-0
R69	68Ω	CMPSN	1/2W 5%	01121	EB6805	27-39524-0
R70	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R71	39Ω	CMPSN	1/4W 5%	01121	CB3905	27-39256-0
R72	1Ω	CMPSN	1/2W 5%	01121	EB10G5	27-39516-0
R73	6.8Ω	CMPSN	1/2W 5%	01121	EB68G5	27-39519-0
R74	6.8Ω	CMPSN	1/2W 5%	01121	EB68G5	27-39519-0
R75	1Ω	CMPSN	1/2W 5%	01121	EB10G5	27-39516-0
R76	39Ω	CMPSN	1/4W 5%	01121	CB3905	27-39256-0
R77	51Ω	CMPSN	1/4W 5%	01121	CB5105	27-39258-0
R78	22Ω	CMPSN	1/2W 5%	01121	EB2205	27-39525-0
R79	100Ω	FILM	1/4W 1%	07115	NA60-1000F	27-42784-0
R80	100Ω	FILM	1/4W 1%	07115	NA60-1000F	27-42784-0
R81	1KΩ	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
SEMICONDUCTORS						
CR11				JEDEC	1N914	27-95001-0
CR12				JEDEC	1N914	27-95001-0
CR13				JEDEC	1N914	27-95001-0
CR14				JEDEC	1N914	27-95001-0
CR15				JEDEC	1N914	27-95001-0
CR16				JEDEC	1N914	27-95001-0
CR17				JEDEC	1N914	27-95001-0
TRANSISTORS						
Q12		MPS6515		04713		29-04538-0
Q13		MPS6515		04713		29-04538-0
Q14		MPS6519		04713		29-04539-0
Q15		MPS6519		04713		29-04539-0
Q16		MPS6515		04713		29-04538-0
Q17		2N5160		04713		29-04525-0
Q18		2N3866		49671		29-04522-0
Q19		MPS6519		04713		29-04539-0
Q20		2N3866		49671		29-04522-0
Q21		2N5160		04713		29-04525-0

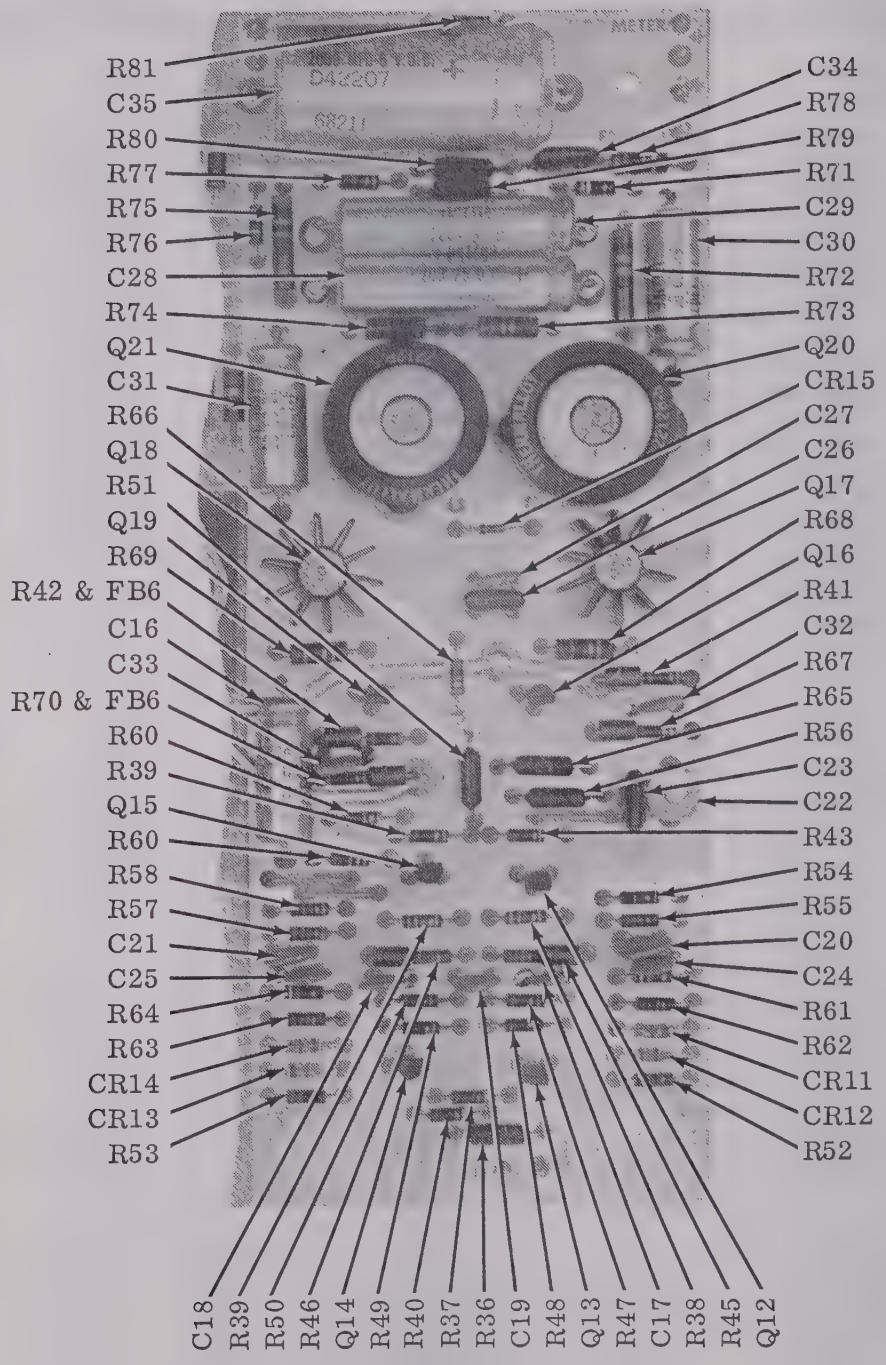
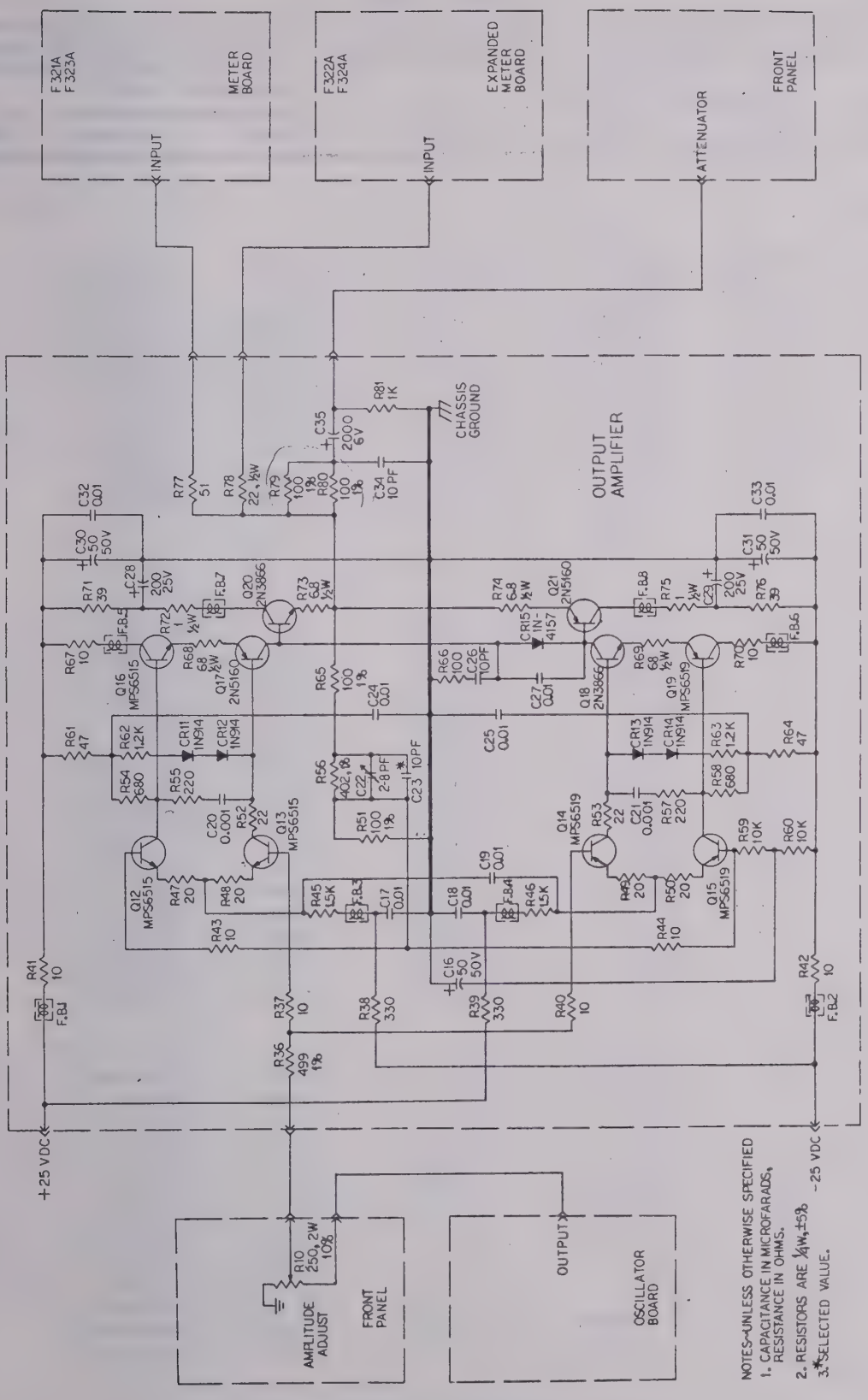


FIGURE 4-3
Output Amplifier Assembly



SCHEMATIC #3 Output Amplifier

PARTS LIST

DATA ROYAL ASSEMBLY: F322A & F324A EXPANDED METER BOARD — DATA ROYAL PART NO. 27-02054-1

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITORS						
C1	200µf	ELCTLT	15V	56289	TE-1164	21-57201-0
C2	5pf	MICA	500V	04062	DM-15-050D	21-57626-0
C3	2-8pf	CER VAR		72982	538-002-89A	21-63201-0
C4	300µf	ELCTLT	6V	56289	TE-1106	21-57207-0
C5	200µf	ELCTLT	15V	56289	TE-1164	21-57201-0
C6	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
C7	10µf	ELCTLT	25V	56289	TE-1204	21-57202-0
C8	10µf	ELCTLT	25V	56289	TE-1204	21-57202-0
C9	0.01µf	CER DISC	100V	56289	TG-S10	21-57001-0
C10	200µf	ELCTLT	15V	56289	TE-1164	21-57201-0
C11	100µf	ELCTLT	15V	56289	TE-1162	21-57224-0
C12	100µf	ELCTLT	15V	56289	TE-1162	21-57224-0
RESISTORS						
R1	100Ω	CMPSN	1/4W 5%	01121	CB1015	27-39261-0
R2	20KΩ	CMPSN	1/4W 5%	01121	CB2035	27-39322-0
R3	8.2KΩ	CMPSN	1/4W 5%	01121	CB8225	27-39285-0
R4	510Ω	CMPSN	1/4W 5%	01121	CB5115	27-39314-0
R5	51Ω	CMPSN	1/4W 5%	01121	CB5105	27-39258-0
R6	51Ω	CMPSN	1/4W 5%	01121	CB5105	27-39258-0
R7	1KΩ	FILM	1/4W 1%	07115	NA60-1001F	27-42846-0
R8	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R9	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
R10	2.4KΩ	CMPSN	1/4W 5%	01121	CB2425	27-39330-0
R11	3.9KΩ	CMPSN	1/4W 5%	01121	CB3925	27-39281-0
R12	15KΩ	CMPSN	1/4W 5%	01121	CB1535	27-39329-0
R13	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R14	100Ω	CMPSN	1/4W 5%	01121	CB1015	27-39261-0
R15	100Ω	VAR	1/2W 10%	01121	SV-1011	27-49510-0
R16	10Ω	CMPSN	1/4W 5%	01121	CB1005	27-39250-0
R17	3.01K	FILM	1/4W 1%	12126	M1/4-3.01K	
R18	470	CMPSN	1/4W 5%	01121	CB4715	27-39269-0
R19	SEL					
R20	6.81K	DEP CARBON	1/4W 1%			27-40752-0
R21	10K	DEP CARBON	1/4W 1%	11350	FCA10-10K	27-40753-0
R22	1K	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
R23	270	CMPSN	1/4W 5%	01121	CB2715	27-39303-0
R24	1K	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
R25	47K	CMPSN	1/4W 5%	01121	CB4735	27-39304-0
R26	3.9K	CMPSN	1/4W 5%	01121	CB3925	27-39281-0
R27	10K	DEP CARBON	1/4W 1%	11350	FCA10-10K	27-40753-0
R28	10K	DEP CARBON	1/4W 1%	11350	FCA10-10K	27-40753-0
R29	100	VAR	1/2W 10%	01121	SV-1011	27-49510-0
R30	549	FILM	1/4W 1%	12126	M1/4-549	27-42824-0
R31	200	FILM	1/4W 1%	07115	NA60-2000F	27-42798-0
R32	5.62K	DEP CARBON	1/4W 1%	11350	FCA10-6810	27-40751-0
R33	3.9K	DEP CARBON	1/4W 1%	11350	FCA10-3900	
R34	SEL					

PARTS LIST

ATA ROYAL ASSEMBLY: F322A & F324A EXPANDED METER BOARD — DATA ROYAL PART NO. 27-02054-1

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
SEMICONDUCTORS						
CR1				JEDEC	1N914	27-95001-0
CR2				JEDEC	1N914	27-95001-0
CR3				JEDEC	1N914	27-95001-0
CR4		MS-7000		21845		27-95254-0
CR5		MS-7000		21845		27-95254-0
CR6				JEDEC	1N914	27-95001-0
TRANSISTORS						
Q1		MPS6519		04713		29-04539-0
Q2		2N5179		49671		29-04512-0
Q3				JEDEC	2N3640	29-04504-0
Q4		40468		49671		29-04517-0
IC1		A741C		28584		25-08713-0
L1		4.7mH		NYTRONICS		21-90000-0
L2		680mH		NYTRONICS		21-90001-0

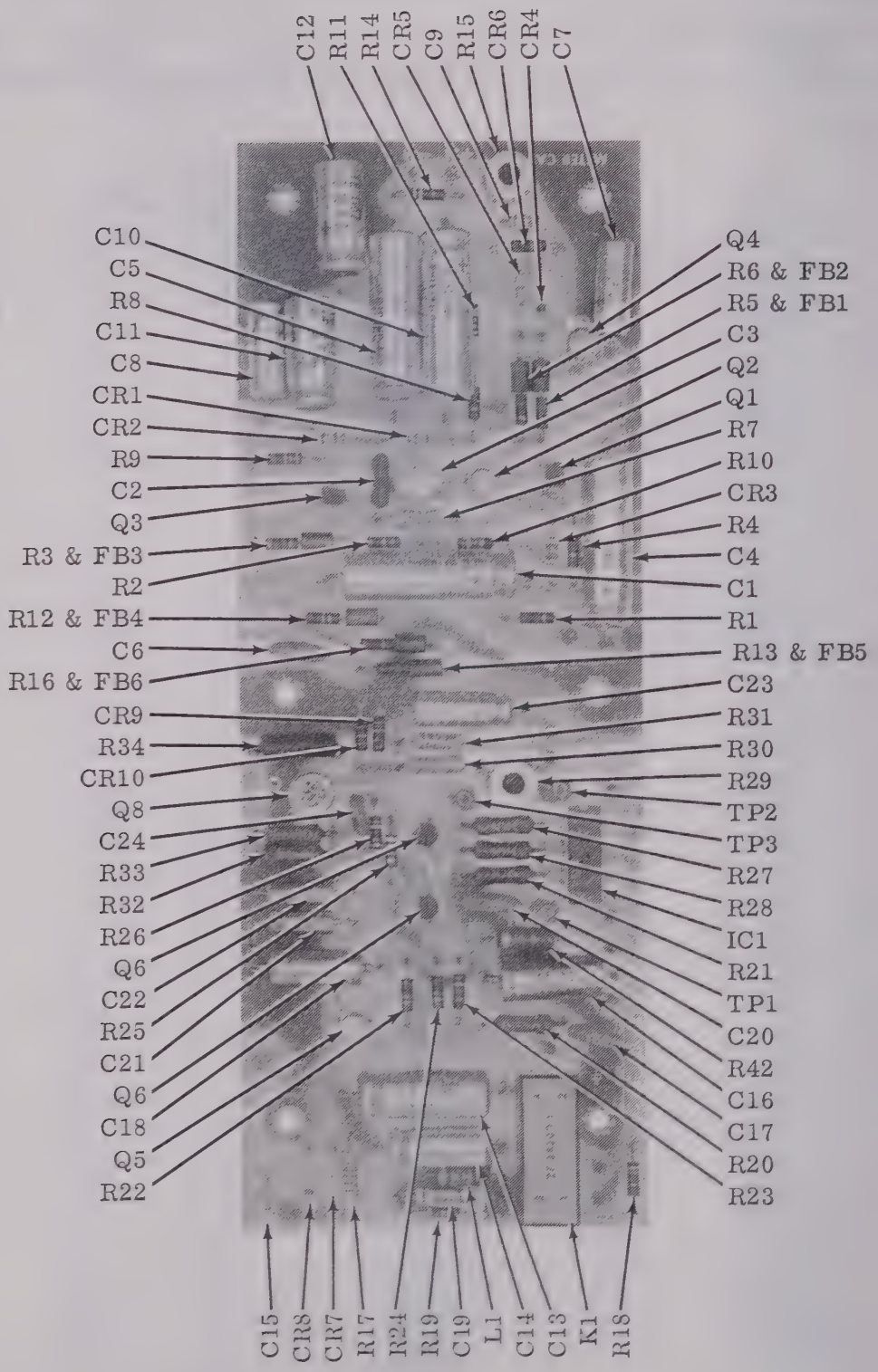
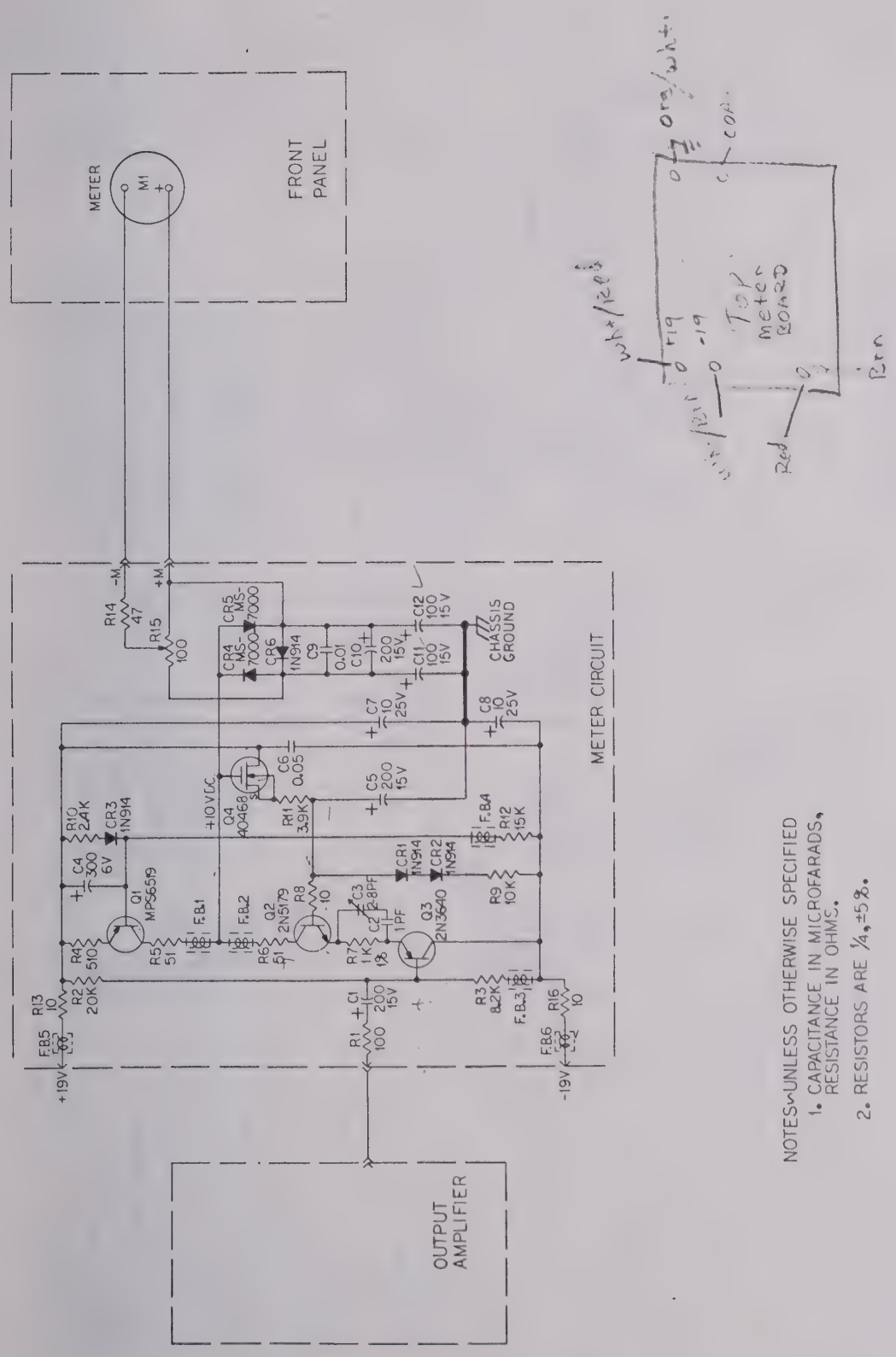


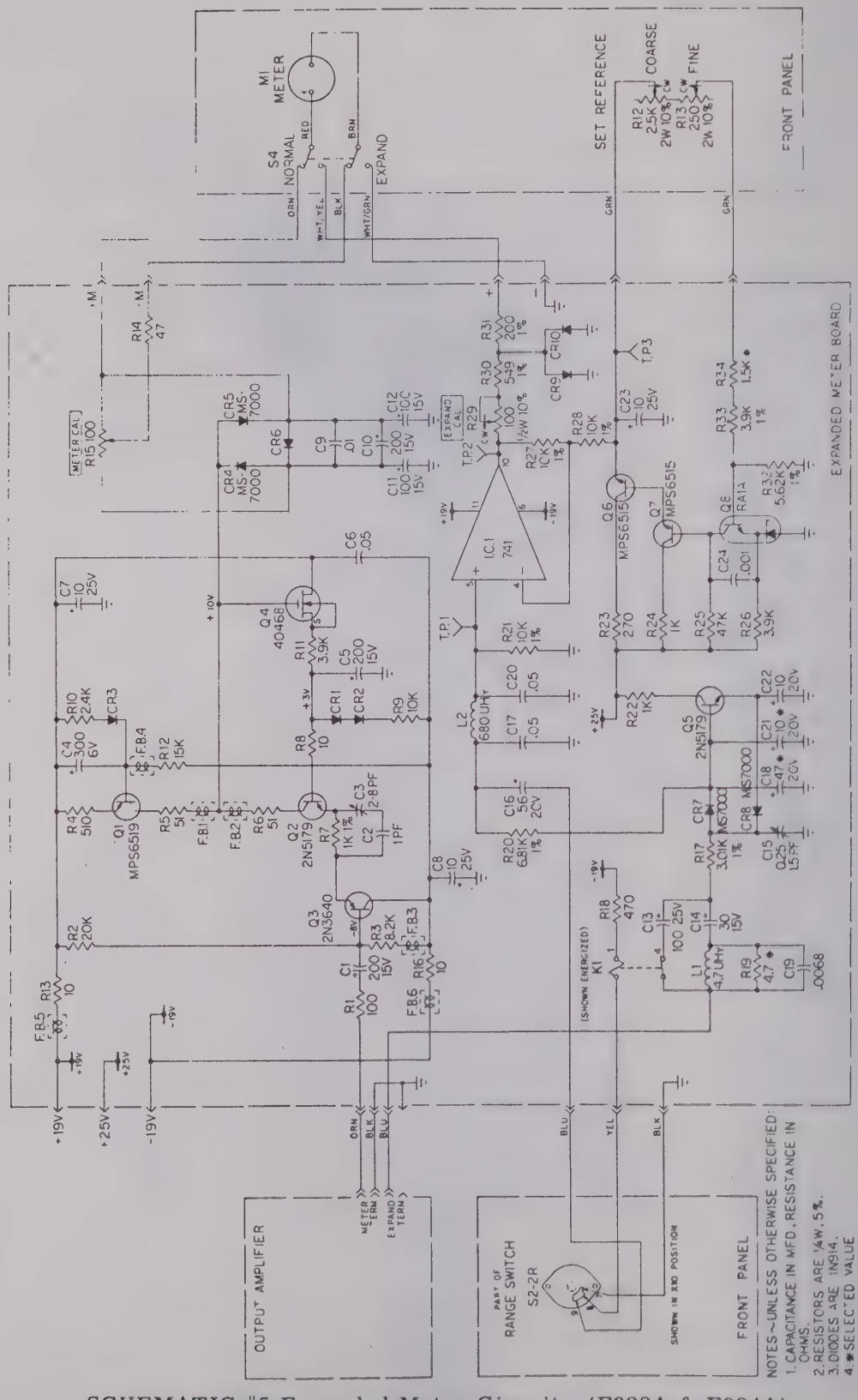
FIGURE 4-4 Expanded Meter Board Assembly



NOTES: UNLESS OTHERWISE SPECIFIED

1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE ¼, ±5%.

SCHEMATIC #4 Meter Circuits (F321A &F323A)

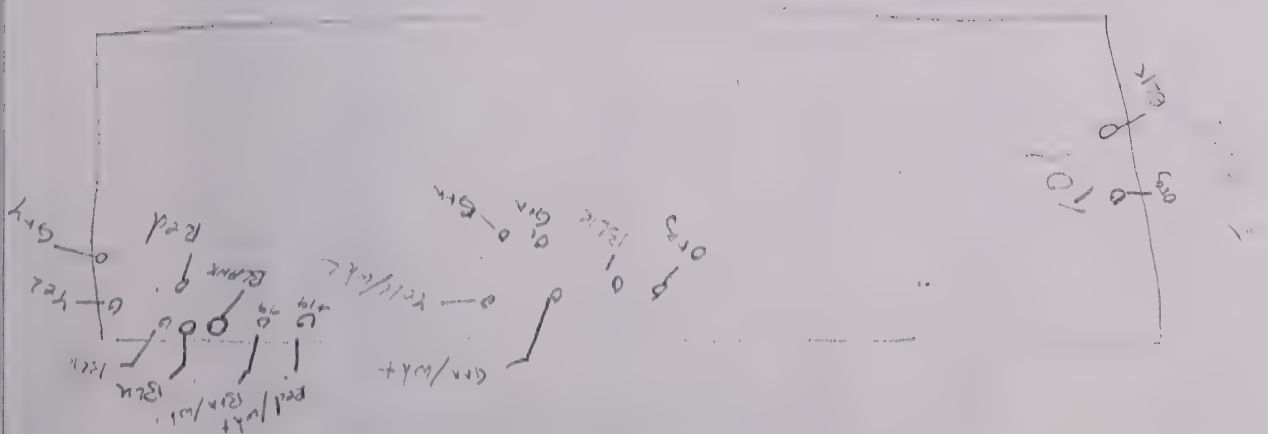


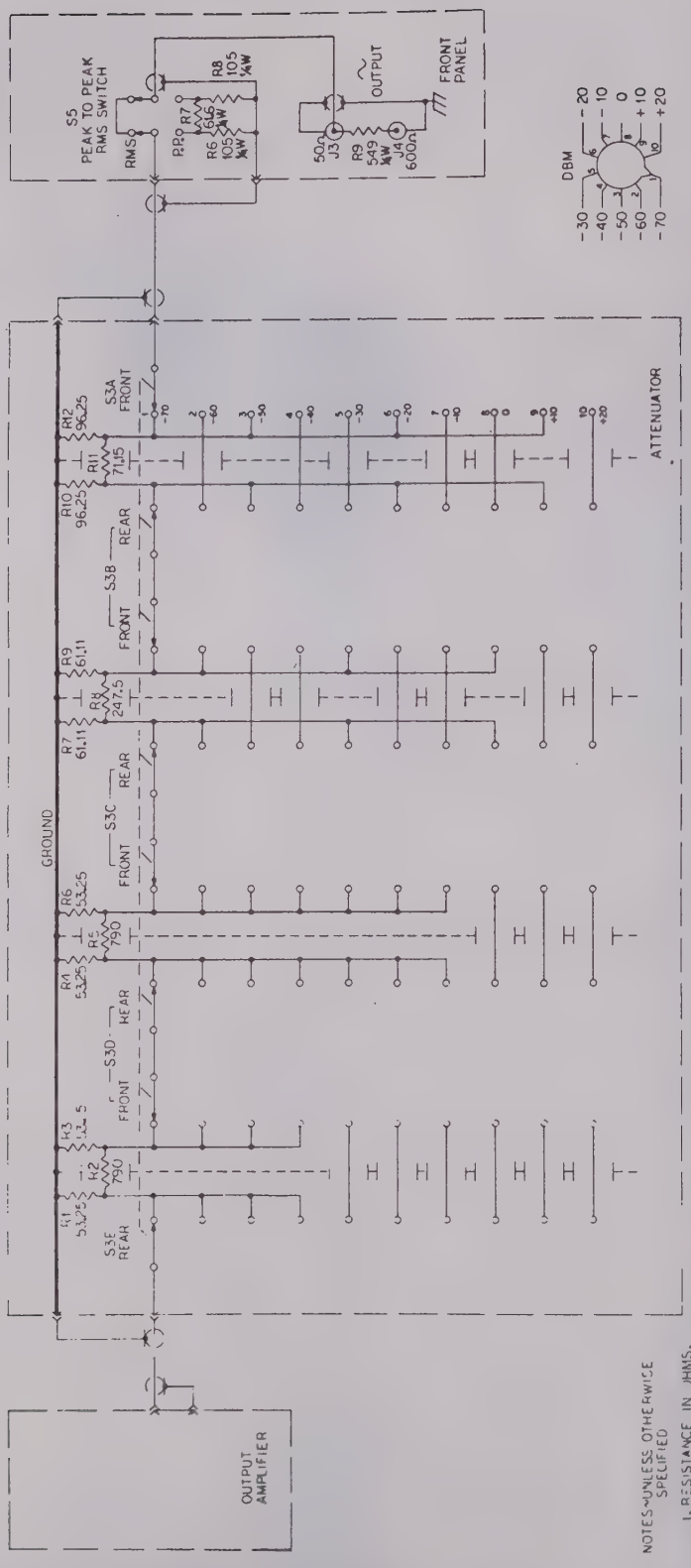
SCHEMATIC #5 Expanded Meter Circuits (F322A & F324A)

PARTS LIST

ATA ROYAL ASSEMBLY: ATTENUATOR — DATA ROYAL PART NO. 29-90083-1

SCHEMATIC ESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
RESISTORS						
R1	53.25Ω	FILM	1/2W 1%	29085		27-46565-1
R2	790Ω	FILM	1/2W 1%	29085		27-46529-1
R3	53.25Ω	FILM	1/2W 1%	29085		27-46565-1
R4	53.25Ω	FILM	1/2W 1%	29085		27-46565-1
R5	790Ω	FILM	1/2W 1%	29085		27-46529-1
R6	53.25Ω	FILM	1/2W 1%	29085		27-46565-1
R7	61.11Ω	FILM	1/2W 1%	29085		27-46566-1
R8	247.5Ω	FILM	1/2W 1%	29085		27-46528-1
R9	61.11Ω	FILM	1/2W 1%	29085		27-46566-1
R10	96.25Ω	FILM	1/2W 1%	29085		27-46567-1
R11	71.15Ω	FILM	1/2W 1%	29085		27-46527-1
R12	96.25Ω	FILM	1/2W 1%	29085		27-46567-1
S3	SWITCH, ROTARY 8POLE/10 POSN			29085		28-64018-1





SCHEMATIC #6 Attenuator (Sealed Unit)

PARTS LIST

A ROYAL ASSEMBLY: POWER SUPPLY — DATA ROYAL PART NO. 29-90080-1

EMATIC GNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
PACITORS						
	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
	1600µf	ELCTLT	50V	Mallory	CGS162V050BB1	21-57222-0
	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
	1600µf	ELCTLT	50V		CGS162V050BB1	21-57222-0
	0.01µf	CER DISC	100V	56289	TG-S10	21-57001-0
	0.01µf	CER DISC	100V	56289	TG-S10	21-57001-0
	220pf	CER DISC	1000V	71590	DD221	21-57014-0
	0.01µf	CER DISC	100V	56289	TG-S10	21-57001-0
	220pf	CER DISC	1000V	71590	DD221	21-57014-0
0	0.01µf	CER DISC	100V	56289	TG-S10	21-57001-0
1	0.01µf	CER DISC	100V	56289	TG-S10	21-57001-0
2	10µf	ELCTLT	25V	56289	TE-1204	21-57202-0
3	10µf	ELCTLT	25V	56289	TE-1204	21-57202-0
4	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
5	0.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
SISTORS						
	1.2Ω	CMPSN	1/2W 5%	01121	EB12G5	27-39500-0
	1.2Ω	CMPSN	1/2W 5%	01121	EB12G5	27-39500-0
	1.2Ω	CMPSN	1/2W 5%	01121	EB12G5	27-39500-0
	680Ω	CMPSN	1/4W 5%	01121	CB6815	27-39271-0
	2KΩ	CMPSN	1/4W 5%	01121	CB2025	27-39277-0
	2KΩ	CMPSN	1/4W 5%	01121	CB2025	27-39277-0
	2KΩ	CMPSN	1/4W 5%	01121	CB2025	27-39277-0
	2KΩ	CMPSN	1/4W 5%	01121	CB2025	27-39277-0
	680Ω	CMPSN	1/4W 5%	01121	CB6815	27-39271-0
)	1.2KΩ	CMPSN	1/2W 5%	01121	EB12G5	27-39500-0
1	1.5KΩ	CMPSN	1/2W 5%	01121	EB1525	27-39523-0
2	1.5KΩ	CMPSN	1/2W 5%	01121	EB1525	27-39523-0
3	1KΩ	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
4	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
5	10KΩ	CMPSN	1/4W 5%	01121	CB1035	27-39286-0
6	1KΩ	CMPSN	1/4W 5%	01121	CB1025	27-39273-0
7	1MΩ	CMPSN	1/4W 5%	01121	CB1055	27-39299-0
8	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
9	1.5KΩ	CMPSN	1/4W 5%	01121	CB1525	27-39275-0
0	2.2KΩ	CMPSN	1/4W 5%	01121	CB2225	27-39278-0
1	1.65KΩ	FILM	1/4W 1%	12126	M1/4-1.65K	27-42857-0
2	14.3KΩ	FILM	1/4W 1%	12126	M1/4-14.3K	27-42988-0
3	19.6KΩ	FILM	1/4W 1%	07115	NA60-1962F	27-42926-0
4	5KΩ	VAR	3/4W 10%	73490	79PR5K	27-49507-0
5	5.49KΩ	FILM	1/4W 1%	07115	NA60-5491F	27-48891-0
6	3.32KΩ	FILM	1/4W 1%	07115	NA60-3321F	27-42872-0
7	3.32KΩ	CMPSN	1/4W 1%	07115	NA60-3321F	27-42872-0
8	680Ω	CMPSN	1/4W 5%	01121	CB6815	27-39271-0
9	680Ω	CMPSN	1/4W 5%	01121	CB6815	27-39271-0
0	100Ω	CMPSN	1/4W 5%	01121	CB1015	27-39261-0
1	100Ω	CMPSN	1/4W 5%	01121	CB1015	27-39261-0
2	7.5Ω	CMPSN	1/2W 5%	01121	EB75G5	27-39520-0
3	7.5Ω	CMPSN	1/2W 5%	01121	EB75G5	27-39520-0
4	4.3KΩ	CMPSN	1/4W 5%	01121	CB4325	27-39327-0
5	4.3KΩ	CMPSN	1/4W 5%	01121	CB4325	27-39327-0

PARTS LIST

DATA ROYAL ASSEMBLY: POWER SUPPLY — DATA ROYAL PART NO. 29-90080-1

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
SEMICONDUCTORS						
CR1		SCE-2		14099	SCE-2	27-95000-0
CR2		SCE-2		14099	SCE-2	27-95000-0
CR3		SCE-2		14099	SCE-2	27-95000-0
CR4		SCE-2		14099	SCE-2	27-95000-0
CR5				JEDEC	1N5244	27-95252-0
CR6				JEDEC	1N5244	27-95252-0
CR7				JEDEC	1N914	27-95001-0
CR8				JEDEC	1N914	27-95001-0
CR9				JEDEC	1N5250B	27-95256-0
CR10				JEDEC	1N5250B	27-95256-0
TRANSISTORS						
Q1				JEDEC	2N3638	29-04503-0
Q2				JEDEC	2N4898	29-04510-0
Q3		40468		49671	40468	29-04516-0
Q4				JEDEC	2N4360	29-04513-0
Q5				JEDEC	2N2218	29-04500-0
Q6		40250		49671	40250	29-04515-0
Q7				JEDEC	2N3638	29-04503-0
Q8		40250		49671	40250	29-04515-0
Q9		MPS6515		04713	MPS6515	29-04538-0
Q10		MPS6519		04713	MPS6519	29-04539-0
Q11				JEDEC	2N4898	29-04510-0
INTEGRATED CIRCUIT						
I.C. 1		μA709C		28584		25-08700-0
I.C. 2		μA709C		28584		25-08700-0

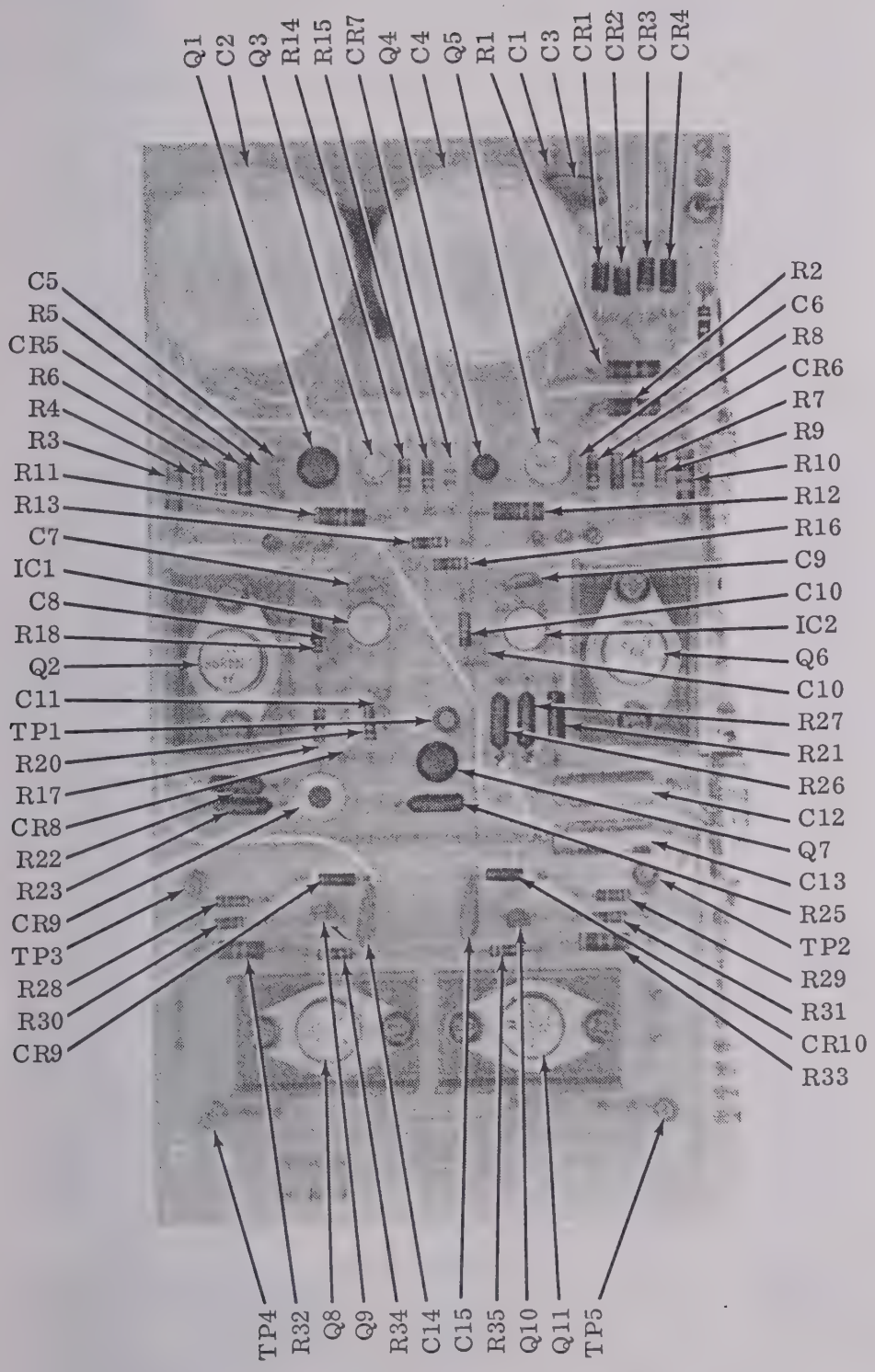
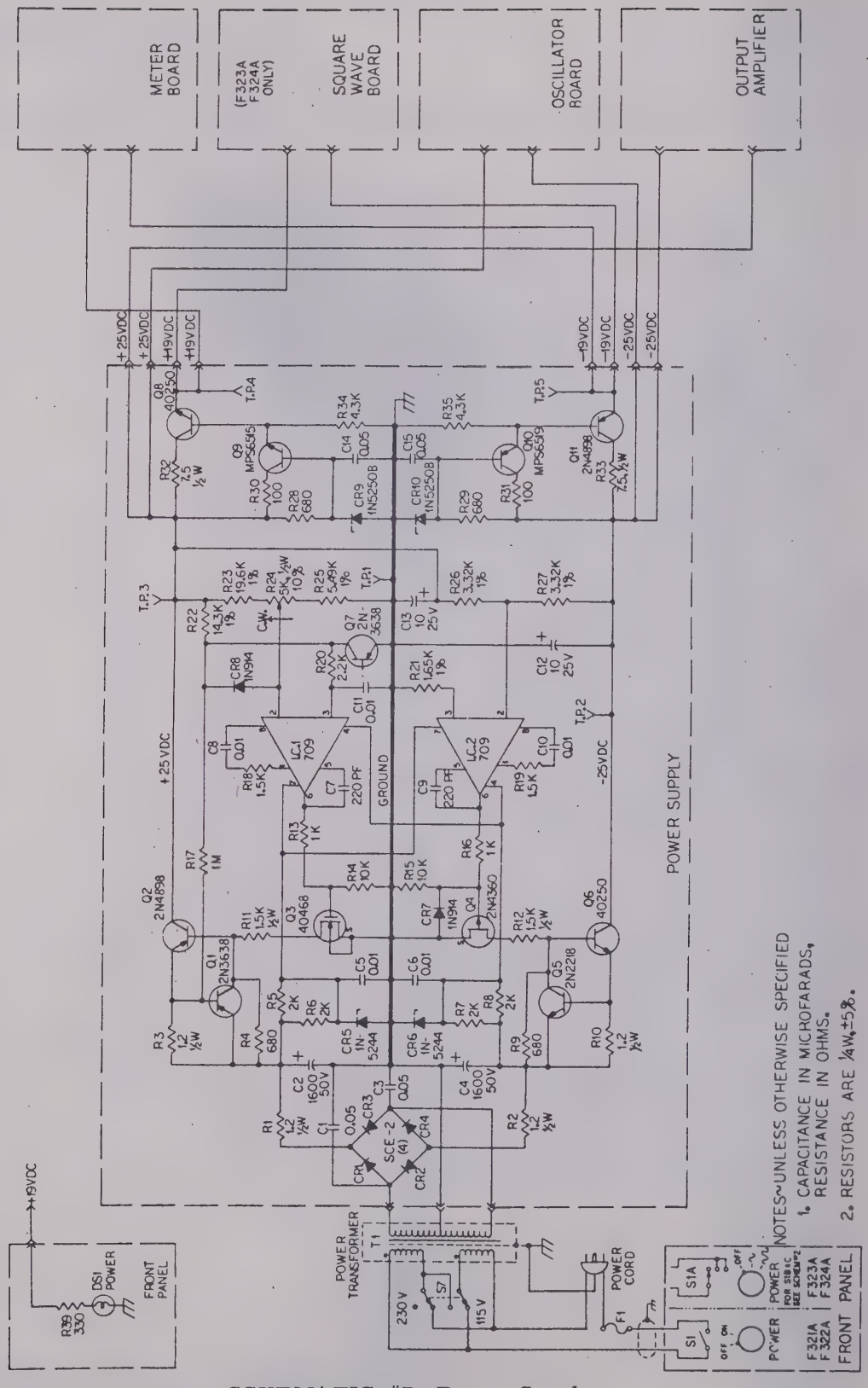


FIGURE 4-6 Power Supply Assembly



SCHEMATIC #7 Power Supply

PARTS LIST

DATA ROYAL ASSEMBLY: F324A FRONT PANEL SUB-ASSEMBLY — DATA ROYAL PART NO. 29-90077-1

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
RESISTORS						
R1	24.9Ω	FILM	1/4W 1%	12126	M1/4-24.9	27-42755-0
R2	50Ω	VAR	1/2W 10%	01121	SV5001	
R3	499Ω	FILM	1/4W 1%	12126	M1/4-499	27-42821-0
R4	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R5	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R6	50Ω	VAR	1/2W 10%	01121	SV5001	
R7	100Ω	VAR	1/4W 20%	71450	X201R3B	27-49519-0
R8	250Ω	VAR	1/4W 20%	71450	X201	27-49520-0
R9	2.5KΩ	VAR	1/4W 20%	71450	X201	27-49527-0
R10	25KΩ	VAR	1/4W 20%	71450	X201	27-49526-0
R11	250KΩ	VAR	1/4W 20%	71450	X201	27-49525-0
R12	2.5MΩ	VAR	1/4W 20%	71590	X201	27-49528-0
R13	121Ω	FILM	1/4W 1%	07115	NA60-1210F	27-42787-0
R14	1.33KΩ	FILM	1/4W 1%	07115	NA60-1331F	27-42850-0
R15	13.3KΩ	FILM	1/4W 1%	07115	NA60-1332F	27-42918-0
R16	133KΩ	FILM	1/4W 1%	07115	NA60-1333F	27-42959-0
R17	1.33MΩ	FILM	1/2W 1%	07115	NA65-1334F	27-43508-0
R18	13.3MΩ	FILM	1W 1%	29085		27-46513-1
R19	121Ω	FILM	1/4W 1%	07115	NA60-1210F	27-42787-0
R20	1.24KΩ	FILM	1/4W 1%	07115	NA60-1241F	27-42849-0
R21	13.3KΩ	FILM	1/4W 1%	07115	NA60-1332F	27-42918-0
R22	133KΩ	FILM	1/4W 1%	07115	NA60-1333F	27-42959-0
R23	1.33MΩ	FILM	1/2W 1%	07115	NA65-1334F	27-43508-0
R24	13.3MΩ	FILM	1W 1%	29085		27-46513-1
R25	100Ω	VAR	1/4W 20%	71450	X201	27-49519-0
R26	250Ω	VAR	1/4W 20%	71450	X201	27-49520-0
R27	2.5KΩ	VAR	1/4W 20%	71450	X201	27-49527-0
R28	25KΩ	VAR	1/4W 20%	71450	X201	27-49526-0
R29	250KΩ	VAR	1/4W 20%	71450	X201	27-49525-0
R30	2.5MΩ	VAR	1/4W 20%	71450	X201	27-49528-0
R31	2.5KΩ	VAR	2W 10%	29085		27-49007-1
R32	250Ω	VAR	2W 10%	29085		27-49005-1
R33	250Ω	VAR	2W 10%	29085		27-49005-1
R34	250Ω	VAR	2W 10%	29085		27-49005-1
R35	61.6Ω	FILM	1/4W 1%	12126	M1/4-61.6	27-46526-0
R36	105Ω	FILM	1/4W 1%	07115	NA60-1050F	27-43509-0
R37	105Ω	FILM	1/4W 1%	07115	NA60-1050F	27-43509-0
R38	549Ω	FILM	1/4W 1%	12126	M1/4-549	27-42824-0
R39	330Ω	CMPSN	1/4W 5%	01121	CB3315	27-39267-0
CAPACITORS						
C1	3-15pf	CER VAR		72982	538-002-110D	21-63202-0
C2	20pf	MICA	500V	04062	DM-15-200J	21-57614-0
C3	9-35pf	CER VAR		72982	538-002-940	21-63200-0
C4	47pf	MICA	500V	04062	DM-15-470J	21-57627-0
C5	9-35pf	CER VAR		72982	538-002-940	21-63200-0
C6	68pf	MICA	500V	04062	DM-15-680J	21-57619-0
C7	15pf	MICA	500V	04062	DM-15-821F	21-57623-0
C8	3-15pf	CER VAR		72982	538-002-110D	21-63202-0
C9	15pf	MICA	500V	04062	DM-15-150J	21-57623-0
C10	9-35pf	CER VAR		72982	538-002-940	21-63200-0
C11	12-532pf	VAR		29085		21-63002-0
DS1	LAMP, INPUT					25-47000-0
M1	METER			29085		25-93000-1
S1	SWITCH, ROTARY	1 POLE / 2 POSN		29085		28-64021-1
S3	SWITCH, TOGGLE	2P2T			7201	28-65002-0

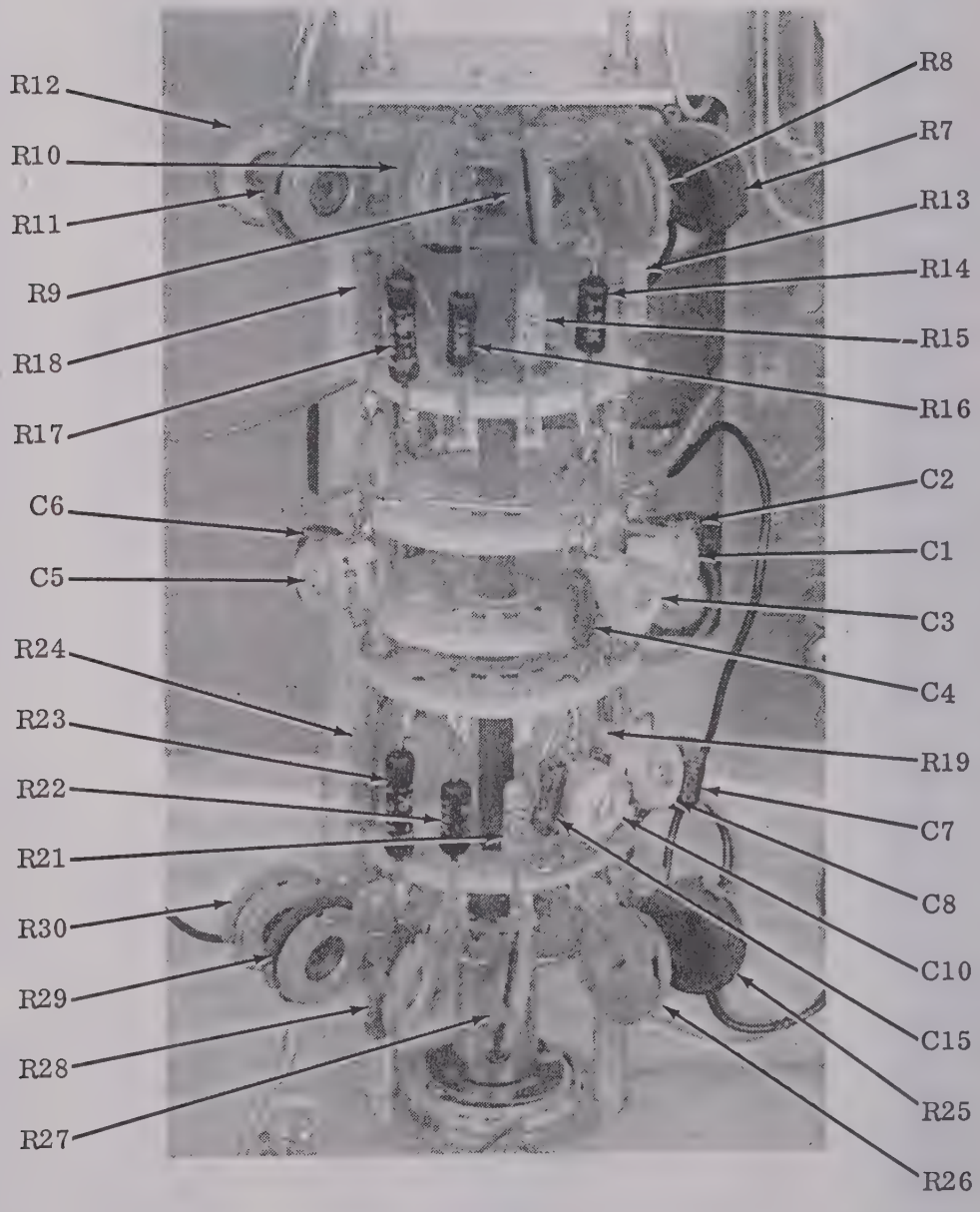


FIGURE 4-7 Range Switch Sub-Assembly

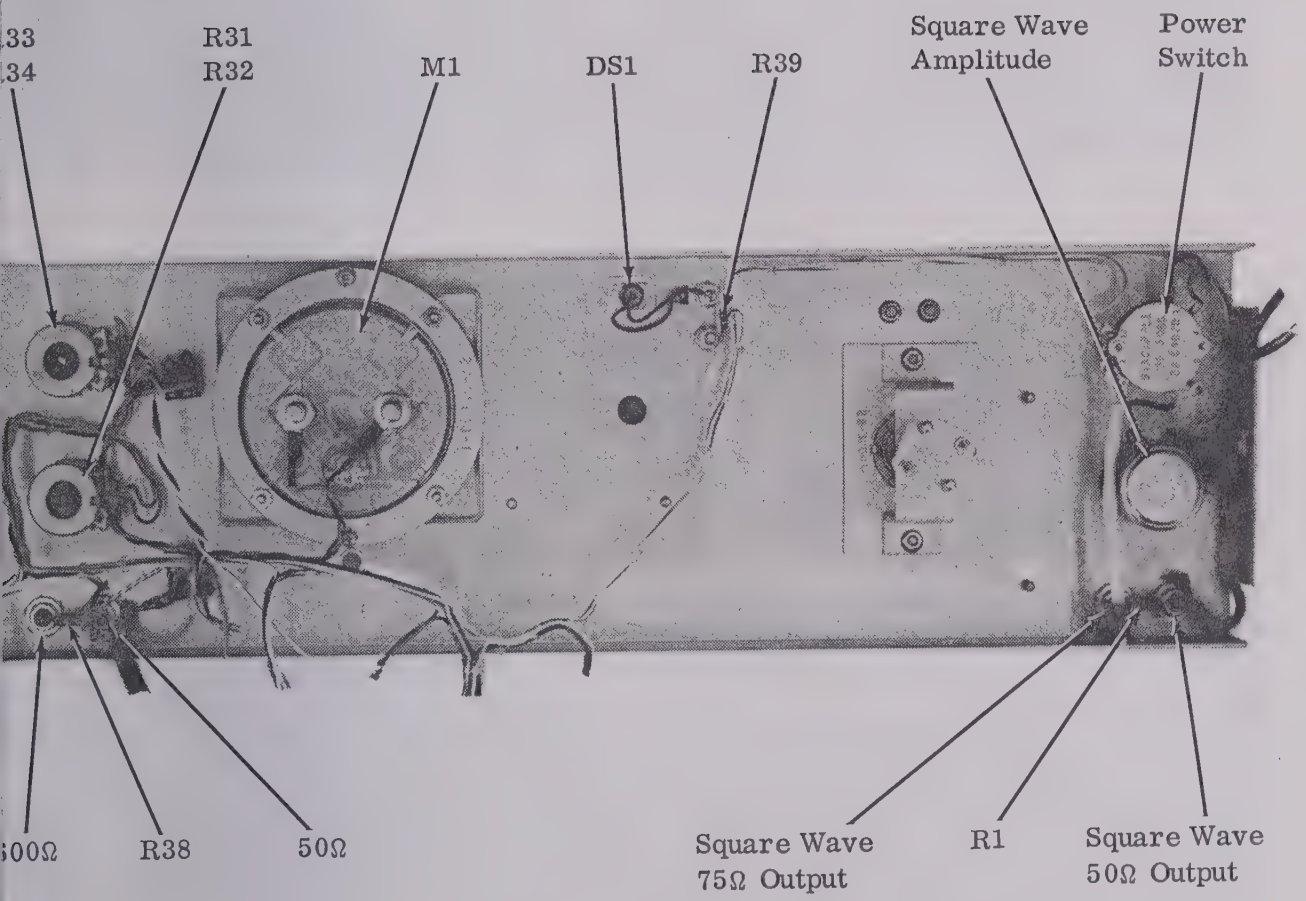
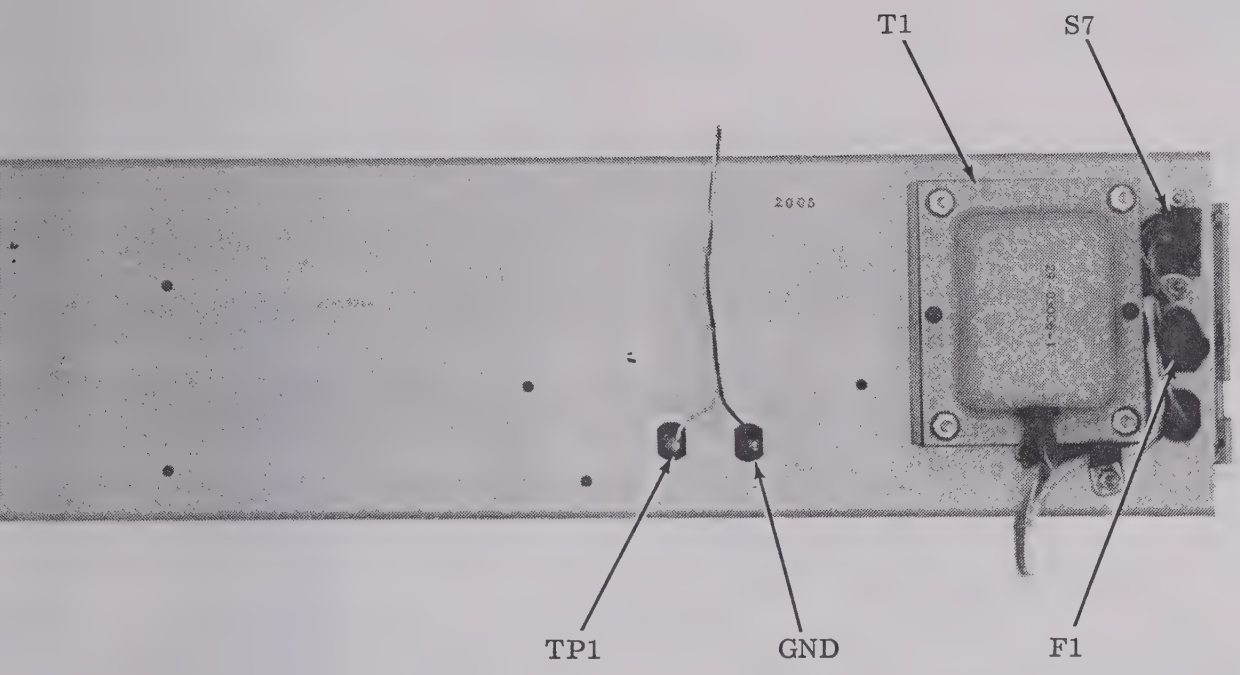


FIGURE 4-8 Front Panel Assembly

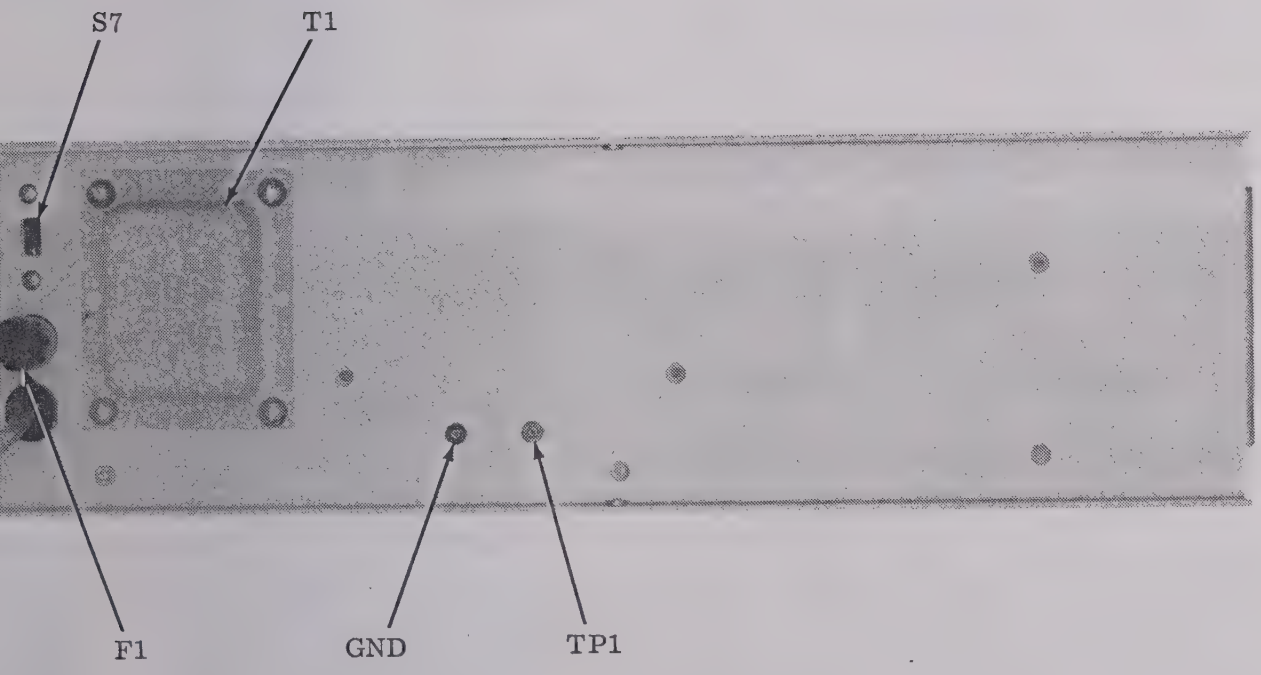
PARTS LIST

DATA ROYAL ASSEMBLY: REAR PANEL SUB-ASSEMBLY — DATA ROYAL PART NO. 29-90078-1

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
T1		POWER TRANSFORMER		29085		29-03006-1
S7		SWITCH, SLIDE		29085		28-64602-1
F1		FUSE	1/4 A SLO-BLO	75915	313.250	24-08001-0



INSIDE VIEW



OUTSIDE VIEW

FIGURE 4-9 Rear Panel Assembly

SECTION V

CALIBRATION AND SPECIFICATION VALIDATION

FREQUENCY:

10 Hz - 10 MHz in 6 continuously variable ranges using 360° dial with >10:1 frequency ratio. 6:1 vernier control provided by concentric dial.

OUTPUT POWER:

200 mW into 50Ω or 16 mW into 600Ω; +23 dBm into 50Ω (0 dBm = 1 mW into 50Ω).

OUTPUT VOLTAGE:

3.16V maximum into 50Ω or 600Ω (6.32 V open circuit), with amplitude control and vernier of >-20 dB.

OUTPUT IMPEDANCE:

Both 50Ω and 600Ω output impedances provided (BNC connectors).

NOTE: Specify Option 01 for 75Ω output impedance in place of 50Ω output impedance.

ATTENUATION -

RANGE:

0-90 dB in -10 dB steps as follows:

Attenuation	Meter Full Scale
+20 dBm (0 dB)	3.16 V
+10 dBm (-10 dB)	1.00 V
0 dBm (-20 dB)	316 mV
-10 dBm (-30 dB)	100 mV
-20 dBm (-40 dB)	31.6 mV
-30 dBm (-50 dB)	10.0 mV
-40 dBm (-60 dB)	3.16 mV
-50 dBm (-70 dB)	1.00 mV
-60 dBm (-80 dB)	316 μV
-70 dBm (-90 dB)	100 μV

NOTE: Additional -9 dB step included for converting meter scale units from rms to p-p.

ACCURACY:

Within ±0.075 dB, -60 dBm to +20 dBm; ±0.2 dB, -70 dBm to -60 dBm.

AMPLITUDE STABILITY:

Within ±2% per month, +20° C to +30° C.

DIAL ACCURACY:

Within ±2% of setting, 100 Hz - 1 MHz; ±3% of setting, 10 Hz - 100 Hz and 1 MHz - 10 MHz. Includes warm-up drift and ±10% line voltage variation.

FREQUENCY RESPONSE - (Flatness)

AMPLITUDE NOT ADJUSTED:

Within ±2%, 100 Hz - 1 MHz; ±3%, 10 Hz - 100 Hz; ±4%, 1 MHz - 10 MHz.

AMPLITUDE ADJUSTED:

Range	Frequency
3.16 V - 1.00 V	1%, 20 Hz - 4 MHz; 2%, 10 Hz - 20 Hz and 4 MHz - 10 MHz.
316 mV - 316 μV	1.5%, 20 Hz - 4 MHz; 2.5%, 10 Hz - 20 Hz and 4 MHz - 10 MHz.
100 μV	2%, 20 Hz - 4 MHz; 3%, 10 Hz - 20 Hz and 4 MHz - 10 MHz.

DISTORTION:
Within 1%, 10 Hz - 2 MHz; 2%, 2 MHz - 5 MHz; 4%, 5 MHz - 10 MHz.

HUM AND NOISE:
Within 0.05% of maximum output.

OUTPUT MONITOR -

NORMAL SCALE:
Monitors output signal level at input to attenuator. Top scale calibrated 0 - 1.0 V rms and 0 - 3.2 V rms. Bottom scale calibrated -15 dBm to +3 dBm (0 dBm = 1 mW into 50Ω).

Accuracy: ±2% of full scale.

EXPAND SCALE: (F322A, F324A)
Expands reference voltage of the Normal Scale from < 0.9 to 1.0 or < 2.8 to 3.2 by approximately 20:1.

Calibration: Normal Scale includes additional calibration for 0%, ±2.5%, with 0.1% increments.

Frequency Response: Within ±0.25%, 3.16 V and 1.00 V ranges; ±0.75%, 316 mV to 316 μV ranges; ±1.75%, 100 μV range.

SQUARE WAVE - (F323A, F324A)

FREQUENCY:
Same as for sine wave.

OUTPUT VOLTAGE:
Continuously variable from 0 to 5 V p-p into a 50Ω or 75Ω load.

OUTPUT IMPEDANCE:
Both 50Ω and 75Ω output impedances provided (BNC connectors).

AMPLITUDE STABILITY:
Short Term: Within ±0.05% of maximum p-p output for at least 10 minutes.

Long Term: Within ±0.25% of maximum p-p output for 24 hours.

DIAL ACCURACY:
Same as for sine wave.

SYMMETRY (TIME):
98%, 10 Hz - 1 MHz and 95%, 1 MHz - 10 MHz.

SYMMETRY (AMPLITUDE):
Within ±1% of maximum p-p output.

RISE AND FALL TIME:
<10 nsec.

OVERSHOOT, PRESHOOT AND TILT:
<5% of p-p amplitude.

OPERATING TEMPERATURE:
0° C to +50° C.

POWER:
115 VAC ±10% or 230 VAC ±10%, 50 Hz - 400 Hz; 30 watts.

NOTE: Except where indicated, specifications apply to signals from 50Ω connector into 50Ω load.

Calibration Procedure:

General.

This section contains operational adjustment procedures, calibration procedures and specification validation procedure for the F320A Sine and Sine/Square Oscillators.

Due to interaction between adjustments, the procedure must be followed in the exact order given.

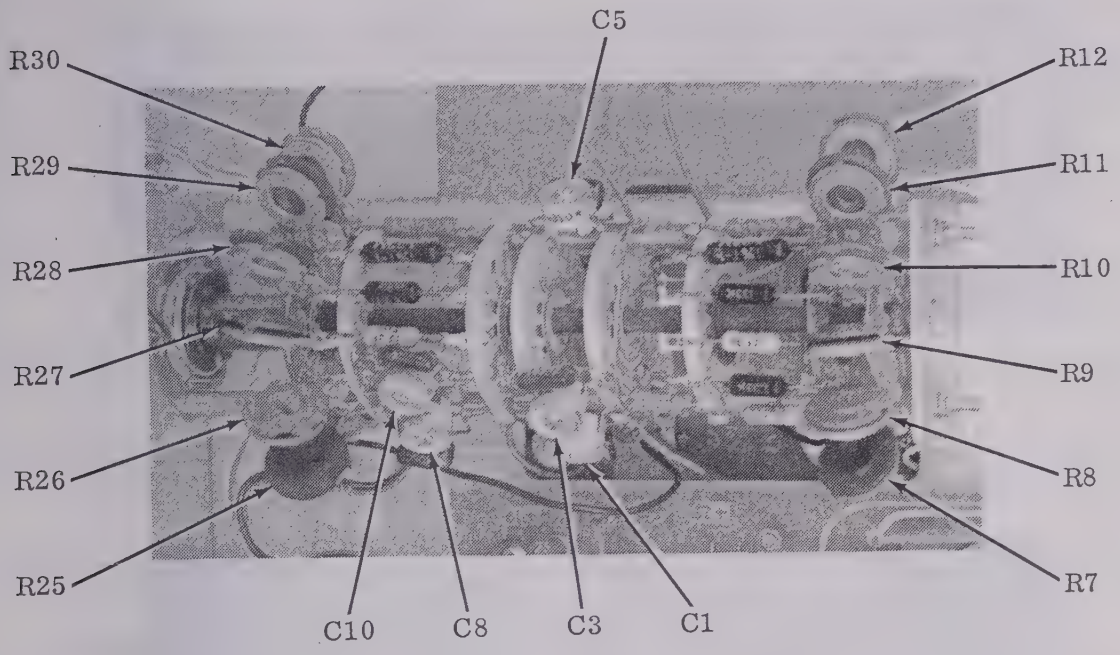


FIGURE 5-1 Range Switch

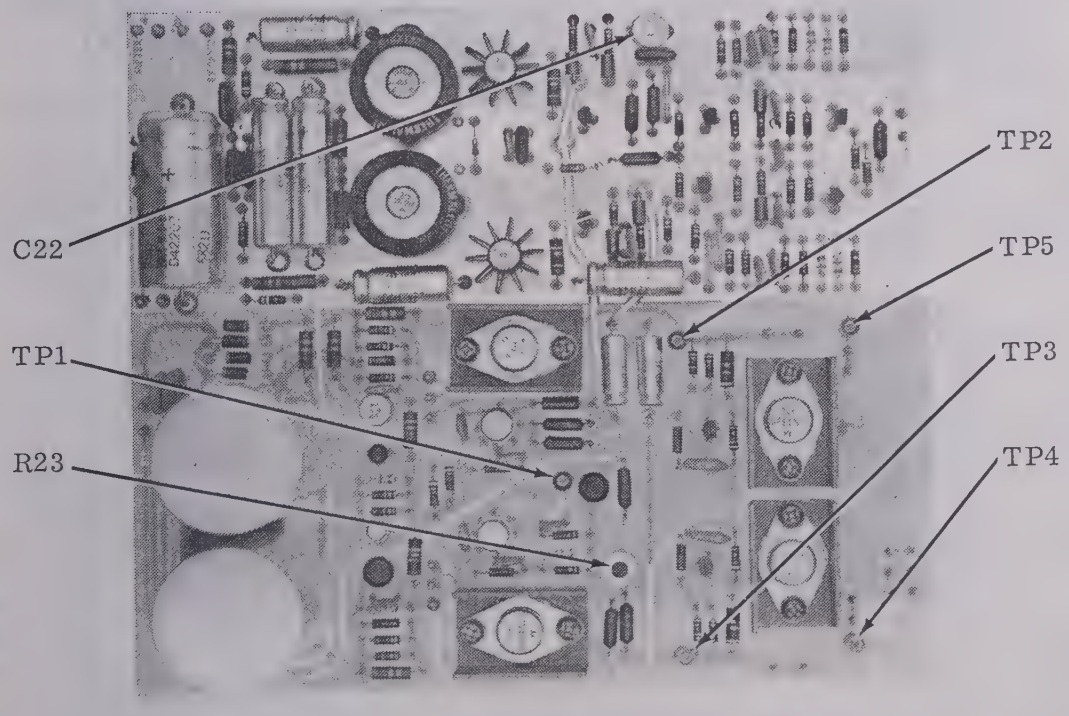


FIGURE 5-2 Power Supply & Output Amplifier

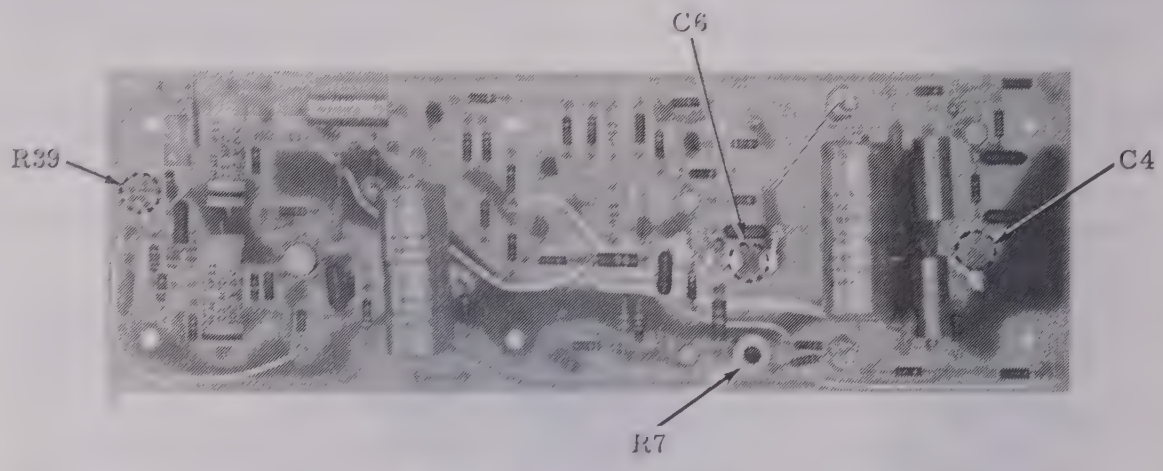


FIGURE 5-3 Oscillator

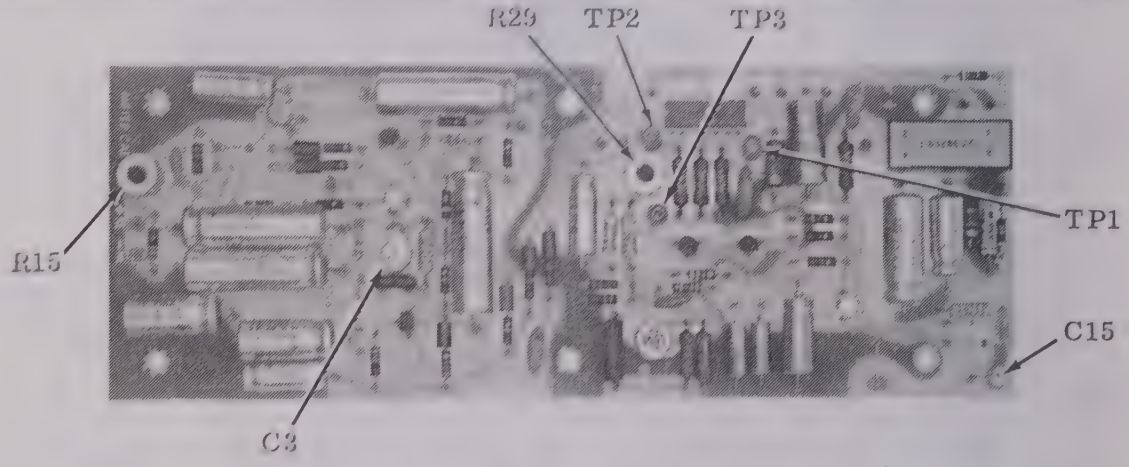


FIGURE 5-4 Expanded Meter Board

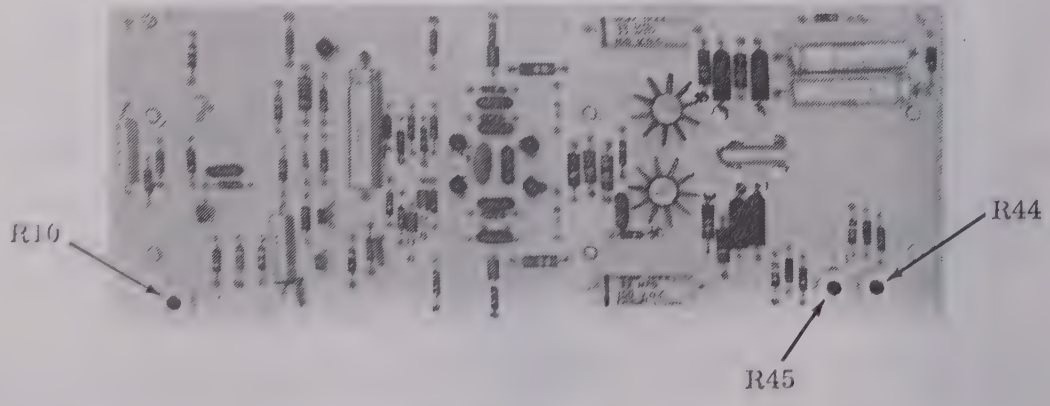


FIGURE 5-5 Square Wave Board

Prior to calibration and/or specification validation, the instrument must be placed in the environment of the work area for sufficient time to allow the internal temperature to stabilize. Warm-up (stabilization) time of 30 minutes is recommended prior to performing the calibration adjustments.

The following test equipment is required to perform the calibration adjustments:

Electronic Counter, Hewlett-Packard Model 5325A, or equivalent.

Digital Multimeter, Cimron Model 7650, or equivalent.

Thermal Converter, Hewlett-Packard Model 11049A, or equivalent.

Oscilloscope, Tektronix, Model 547, (W/1A1 Plug-in), or equivalent.

VTVM, Hewlett-Packard, Model 3400A, or equivalent.

Calibration Procedure

OPERATIONAL ADJUSTMENTS:

See Figure 5-1 for location of test points and calibration adjustments.

a. Position controls as follows:

Power	ON
F321A, F322A	ON
F323A, F324A	Sine, Square
Frequency Range	X1K
Frequency Dial	5
Attenuator	+20dB
Amplitude	Clockwise
RMS/P-P	RMS
NORMAL/EXPAND	
F322A, F324A Only	NORMAL

b. Using a pair of short clip leads, short R10 and R28 on the Range Switch.

c. Connect a Digital Voltmeter to TP3.

d. Adjust R24 on the Power Supply for a reading of 25.00 volts.

e. Measure TP2. Reading should be -25.00 volts ±.2 volts.

f. Measure TP4 and TP5. Readings should be +19 and -19 volts, ±1 volt.

g. Connect the DVM to TP1. (Red TP on the rear panel).

h. Position the Frequency Dial to 1.

i. Adjust R7 on the Oscillator Board for a reading of -2.5 volts.

j. Remove the clip leads from R10 and R28.

k. Connect the VTVM to the 50Ω Sine Wave output connector. Terminate the output in 50Ω at the input to the VTVM.

l. Adjust R39 on the Oscillator Board for an indication of 3.2 volts RMS.

m. Adjust R15 on the Meter Board for a reading of 3.2 volts on the Output Level Meter.

n. Position the Range Switch to X1M.

o. Adjust C3 on the Meter Board for a reading of 3.2 volts on the Output Level Meter.

Expanded Meter Adjustments:
(F322A and F324A only).

a. Position Controls as in a. above.

b. Connect the DVM to the 50Ω Sine Wave

Output connector. Terminate the output in 50Ω at the input to the DVM.

c. Adjust the front panel Amplitude Control for a reading of 3.000 volts on the DVM.

d. Position the Reference Set Controls (Coarse and Fine) to the center of their range.

e. Position the Normal/Expand Switch to Expand. Output Level Meter should read near 0 (zero).

f. Position the Reference Set Control for an indication of 0% on the Output Level Meter Expand Scale.

g. Adjust the front panel Amplitude Control for a reading of 3.075 volts on the DVM (+2.5% increase).

h. Adjust R29 on the Meter Board for an indication of +2.5% on the Output Level Meter Expand Scale.

i. Repeat Step c. through h. until no further adjustment of R29 is needed.

Square Wave Adjustments:
(F323A and F324A only)

a. Position all controls as in a. above.

b. Connect the Oscilloscope to the 50Ω Square Wave output connector. Terminate the output in 50Ω at the input to the Oscilloscope. (Scope DC coupled.)

c. Adjust R10 on the Square Wave Board for 100% Time Symmetry.

d. Adjust R44 on the Square Wave Board for +2.5 volt amplitude, and R45 for -2.5 volt amplitude.

FREQUENCY CALIBRATION:

a. Position controls as follows:

Power	
(F321A, F322A)	ON
(F323A, F324A)	Sine, Square
Frequency Range	X1K
Frequency Dial	1
Attenuator	+20 dB
Amplitude	Clockwise
RMS/P-P	RMS
Normal/Expand	
(F322A, F324A)	Normal

b. Connect the DVM to TP1 on the rear panel.

c. Connect the counter to the 50Ω Sine Wave output connector.

NOTE

The voltage at TP1 shall be maintained at -2.5 volts ±.1 volts for all calibration adjustments (except 10 MHz, see below).

d. Alternating between R10 and R28, adjust for a reading of 1.000 KHz, while maintaining the voltage at TP1.

e. Position the Frequency Dial to 10.

f. Alternating between C4 on the Oscillator Board and C5 on the Range Switch, adjust for a frequency of 10.00 KHz, while maintaining the voltage at TP1.

g. Position the Range Switch to X10.

h. Alternating between R12 and R30 on the Range Switch, adjust for a frequency of 100.0 KHz, maintaining the voltage at TP1.

i. Position the Range Switch to X100.

j. Alternating between R11 and R29 on the Range Switch, adjust for a frequency of 1.000 KHz, maintaining the voltage at TP1.

k. Position the Range Switch to X10K.

l. Alternating between R9 and R27 on the Range Switch, adjust for a frequency of 100.0 KHz, maintaining the voltage at TP1.

m. Position the Range Switch to X100K, and the Frequency Dial to 1.

n. Alternating between R8 and R26 on the Range Switch, adjust for a frequency of 100.0 KHz, maintaining the voltage at TP1.

o. Position Frequency Dial to 10.

p. Alternating between C3 and C10 on the Range Switch, adjust for a frequency of 1.000 MHz, maintaining the voltage at TP1.

q. Position the Range Switch to X1M, and the Frequency Dial to 1.

r. Alternating between R7 and R25 on the Range Switch, adjust for a frequency of 1.000 MHz, maintaining the voltage at TP1.

s. Position the Frequency Dial to 10.

t. Alternating between C1 and C8 on the Range Switch, adjust for a frequency of 10.15 MHz (1.5% high), and maintain a voltage of -2.7 volts at TP1 ±.1 volts. Panel Amplitude Control must be fully clockwise.

u. Repeat Steps m. through t. until voltage and frequency conditions are satisfied.

AMPLITUDE ADJUSTMENT:

a. Connect the Thermal Converter to the 50 Output Connector.

b. Connect the DVM to the output of the Thermal Converter.

c. Position the Amplitude Control on the front panel to its fully clockwise position.

d. Position the Range Switch to X1K, and the Frequency Dial to 10.

e. Observe and record the reading on the DVM.

f. Position the Range Switch to X1M.

g. Adjust C22 on the AMP. Oscillator Board for the same indication on the DVM.

Specification Validation:

Prior to performing the specification validation, ensure that the operational and calibration adjustment procedures have been performed completely.

Before rejecting an instrument for inability to meet all specifications, be certain the test equipment specifications are equal to, or better than, those given in the list of required test equipment.

The following test equipment, or equivalent, is required to validate the F320A Series specifications.

Electronic Counter
Hewlett-Packard Model 5325A

Attenuator
Hewlett-Packard Model 355D

Digital Multimeter
Cimron Model 7650

AC Voltmeter
Hewlett-Packard Model 3400A

Distortion Analyzer
Hewlett-Packard Model 333A

Distortion Meter
Boonton Model 85B

Thermal Converter
Hewlett-Packard, Model 11049A

Frequency Range and Dial Accuracy:

a. Interconnect equipment as shown in Figure 5-6, observing signal and ground connections carefully. Terminate the output in a 50Ω load at the input to the counter.

b. Position the controls as follows:

Power	OFF
Frequency Range	X10
Frequency Dial	1
Amplitude	Mid-range
Attenuator	+20
Impedance	50Ω Output Connector
RMS/P-P Switch	RMS

c. Turn the Power Switch to the ON (Sine, Square) position.

d. Observe that the counter indicates a frequency of 10.0 Hz ±3%.

e. Position the Range Switch to X100.

f. Observe that the counter indicates a frequency of 100Hz ±2%.

g. Position the Range Switch to X1K.

h. Observe that the counter indicates a frequency of 1.00KHz ±2%.

i. Position the Range Switch to X10K.

j. Observe that the counter indicates a frequency of 10.0KHz ±2%.

k. Position the Range Switch to X100K.

l. Observe that the counter indicates a frequency of 100KHz ±2%.

m. Position the Range Switch to X1M.

n. Observe that the counter indicates a frequency of 1.00MHz ±3%.

o. Position the Frequency Dial to 5.

p. Observe that the counter indicates a frequency of 5.00MHz ±3%.

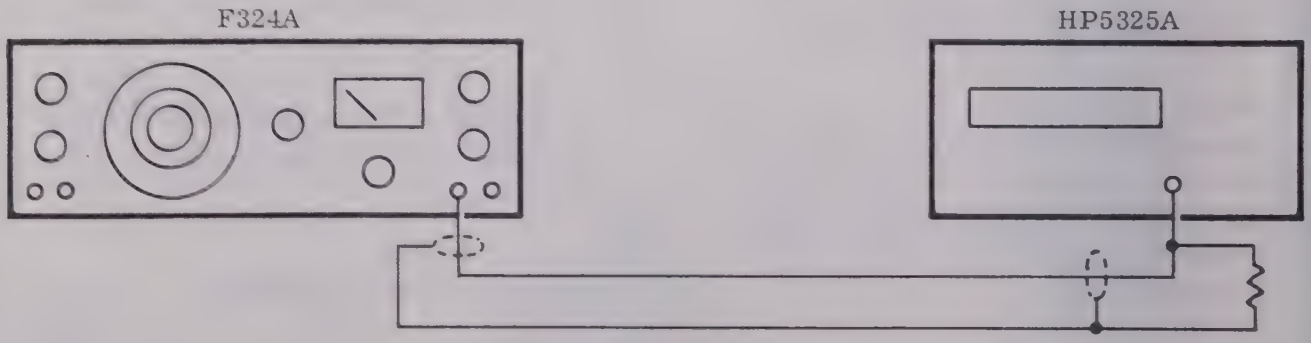


FIGURE 5-6

q. Position the Range Switch to X100K.

r. Observe that the counter indicates a frequency of 500 KHz ±2%.

s. Position the Range Switch to X10K.

t. Observe that the counter indicates a frequency of 50.0KHz ±2%.

u. Position the Range Switch to X1K.

v. Observe that the counter indicates a frequency of 5.00KHz ±2%.

w. Position the Range Switch to X100.

x. Observe that the counter indicates a frequency of 500Hz ±2%.

y. Position the Range Switch to X10.

z. Observe that the counter indicates a frequency of 50.0 Hz ±3%.

aa. Position the Frequency Dial to 10.

ab. Observe that the counter indicates a frequency of 100 Hz ±3%.

ac. Position the Range Switch to X100.

ad. Observe that the counter indicates a frequency of 1.00KHz ±2%.

ae. Position the Range Switch to X1K.

af. Observe that tthe counter indicates a frequency of 10.0KHz ±2%.

ag. Position the Range Switch to X10K.

ah. Observe that the counter indicates a frequency of 100KHz ±2%.

ai. Position the Range Switch to X100K.

aj. Observe that the counter indicates a frequency of 1.00 MHz ±2%.

ak. Position the Range Switch to X1M.

al. Observe that the counter indicates a frequency of 10.0MHz ±3%.

Frequency Response:

a. Interconnect equipment as shown in Figure 5-7, observing signal and ground connections carefully. Terminate the output in a 50Ω load.

b. Position controls as follows:

Power	OFF
Frequency Range	X100
Frequency Dial	10
Amplitude	Counter-clockwise
Attenuator	+20
Impedance	50Ω Output Connector
RMS/P-P Switch	RMS

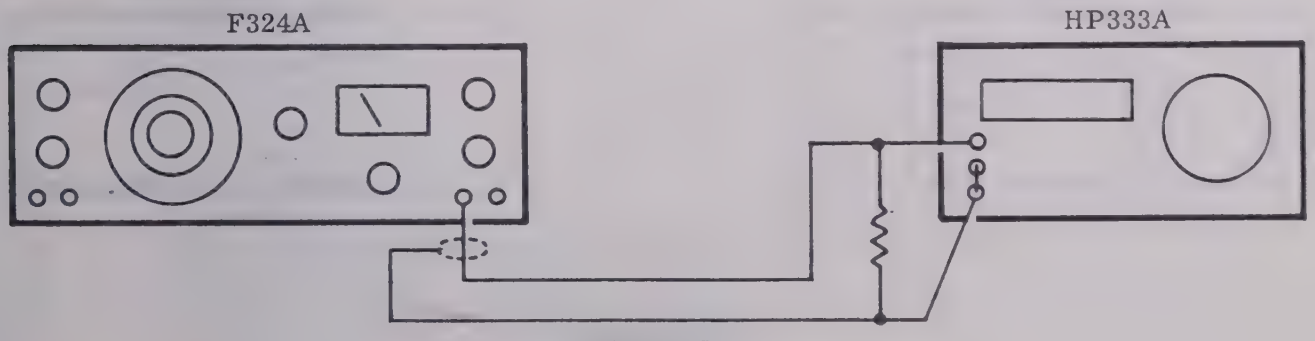


FIGURE 5-7

c. Turn the Power Switch to the ON (Sine, Square) position.

d. Adjust the Amplitude Control for an indication of 0 dB on the 3 volt range of the HP333A.

e. Position the Frequency Dial to 1.

f. Observe that the HP333A indicates the same reading as in step d. ±0.2 dB.

g. Position the Range Switch to X10.

h. Observe that the HP333A indicates the same reading as in step d. ±0.3 dB.

i. Position the Frequency Dial to 10.

j. Observe that the HP333A indicates the same reading as in step d. ±0.3 dB.

k. Position the Range Switch to X1K.

l. Observe that the HP333A indicates the same reading as in step d. ±0.2 dB.

m. Position the Range Switch to X10K.

n. Observe that the HP333A indicates the same reading as in step d. ±0.2 dB.

o. Interconnect the equipment as shown in Figure 5-8, observing signal and ground connections carefully. Do NOT terminate the output.

p. Position controls as follows:

Power	OFF
Frequency Range	X100K
Frequency Dial	1
Amplitude	Counter-clockwise
Impedance	50 Output Connector
RMS/P-P Switch	RMS

q. Turn the Power Switch to the ON (Sine, Square) position.

r. Adjust the Amplitude Control for an indication of -2 dB on the 3 volt range of the Boonton 85B.

s. Position the Frequency Dial to 10.

t. Observe that the Boonton 85B indicates the same reading as in step r. ±0.2 dB.

u. Position the Range Switch to X1M.

v. Observe that the Boonton 85B indicates the same reading as in step r. ±0.3 dB.

w. Position the Frequency Dial to 1.

x. Observe that the Boonton 85B indicates

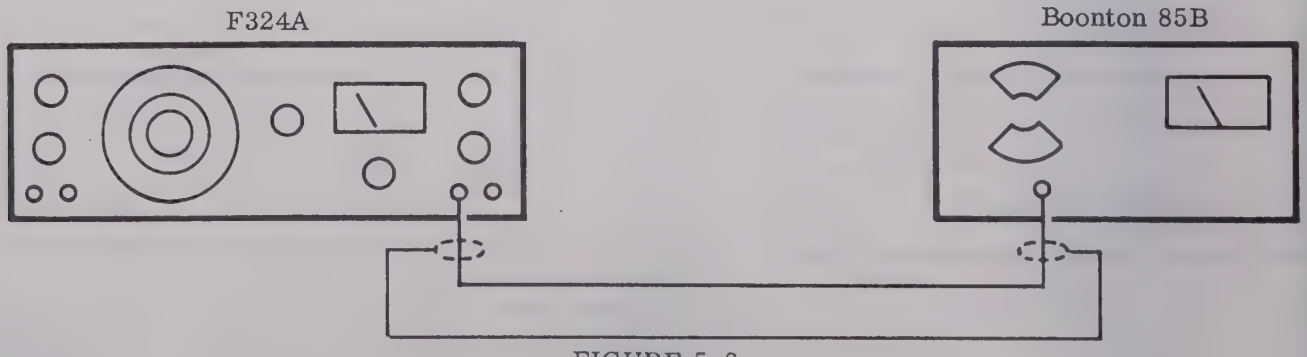


FIGURE 5-8

the same reading as in step r. ±0.3 dB.

Output Power:

a. Interconnect equipment as shown in Figure 5-9, observing signal and ground connections carefully. Do NOT terminate the output.

b. Position controls as follows:

Power	OFF
Frequency Range	X10
Frequency Dial	10
Amplitude	Clockwise
Attenuator	+20
Impedance	See below
RMS/P-P Switch	RMS

c. Turn the Power Switch to the ON (Sine, Square) position.

d. Connect the Digital Multimeter to the 50Ω Output Connector, and terminate the output in a 50Ω load.

e. Observe that the Digital Multimeter indicates a reading of at least 3.1600 volts.

NOTE: 3.16 volts into 50Ω = 200 mw.

f. Disconnect the Digital Multimeter, and remove the 50Ω load.

g. Connect the Digital Multimeter on the 600Ω Output Connector, and terminate the output in a 600Ω load.

h. Observe that the Digital Multimeter indicates a reading of at least 3.16 volts.

NOTE: 3.16 volts into 6000Ω = 16 mw.

i. Turn the Amplitude Control fully counterclockwise.

j. Observe that the reading on the Digital Multimeter drops to 300 mv or less (>-20 dB).

Attenuator:

a. Interconnect equipment as shown in Figure 5-10, observing signal and ground connections carefully. Terminate the output in a 50Ω load.

b. Position controls as follows:

Power	OFF
Frequency Range	X1K
Frequency Dial	1
Amplitude	Clockwise
Attenuator	+20
Impedance	50Ω Output Connector
RMS/P-P Switch	RMS

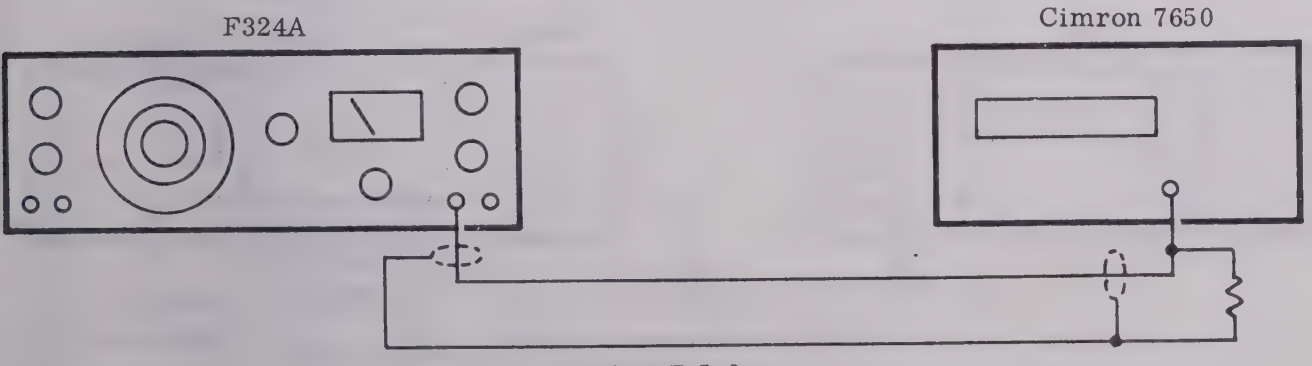


FIGURE 5-9

c. Turn the Power Switch to the ON (Sine, Square) position.

d. Position the 355D to the -90 dB position, and the 400F to -80 dB.

e. Adjust the Amplitude Control for an indication of 0 dB on the 400F.

f. Sequentially position the Attenuator from +20 to -60, while positioning the 355D from -90 to -10.

g. Observe that the attenuation of each step is -10 dB ±.075 dB.

h. Position the Attenuator to the -70 position, and the 355D to 0 dB.

i. Observe that the attenuation is -10 dB ±0.2 dB.

j. Interconnect equipment as shown in Figure 5-11, observing signal and ground connections carefully.

k. Position controls as follows:

Power	OFF
Frequency Range	X10K
Frequency Dial	10
Amplitude	Clockwise
Attenuator	+20
RMS/P-P Switch	RMS
Impedance	50 Output Connector

l. Turn the Power Switch to the ON (Sine, Square) position.

m. Position the 355D to the -90 dB position, the 400F to the 1A1 plug-in to 5mv/cm, and the 85B to the .003V range.

n. Adjust the Amplitude Control for an indication on the 85B of 1 dB.

o. Sequentially position the Attenuator from +20 to -60, while positioning the 355D from -90 to -10 dB.

p. Observe that attenuation of each step is -10 dB ±.075 dB.

q. Position the Attenuator to the -70 position and the 355D to 0 dB.

r. Observe that the attenuation of each step is -10 dB ±0.2 dB.

s. Repeat steps m. through r. for frequencies of 1 MHz and 10 MHz.

Distortion:

a. Interconnect equipment as shown in Figure 5-12, observing signal and ground connections carefully. Terminate the

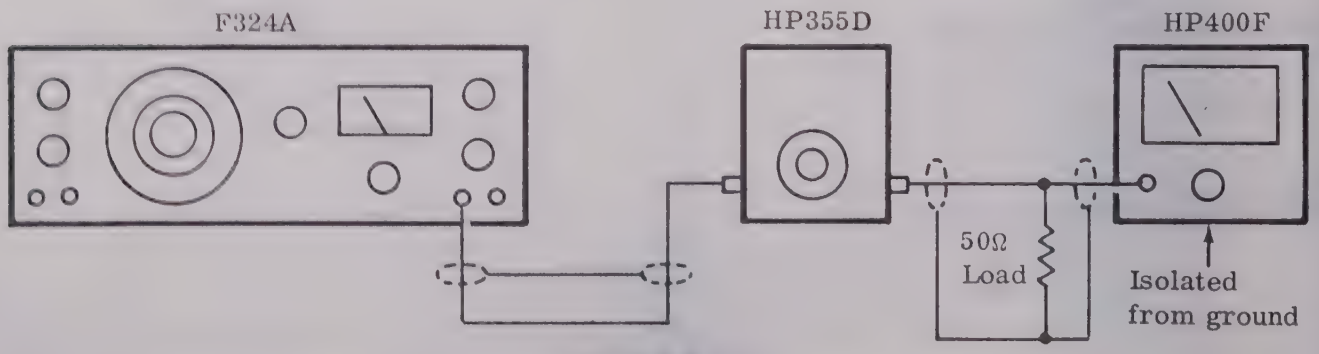


FIGURE 5-10

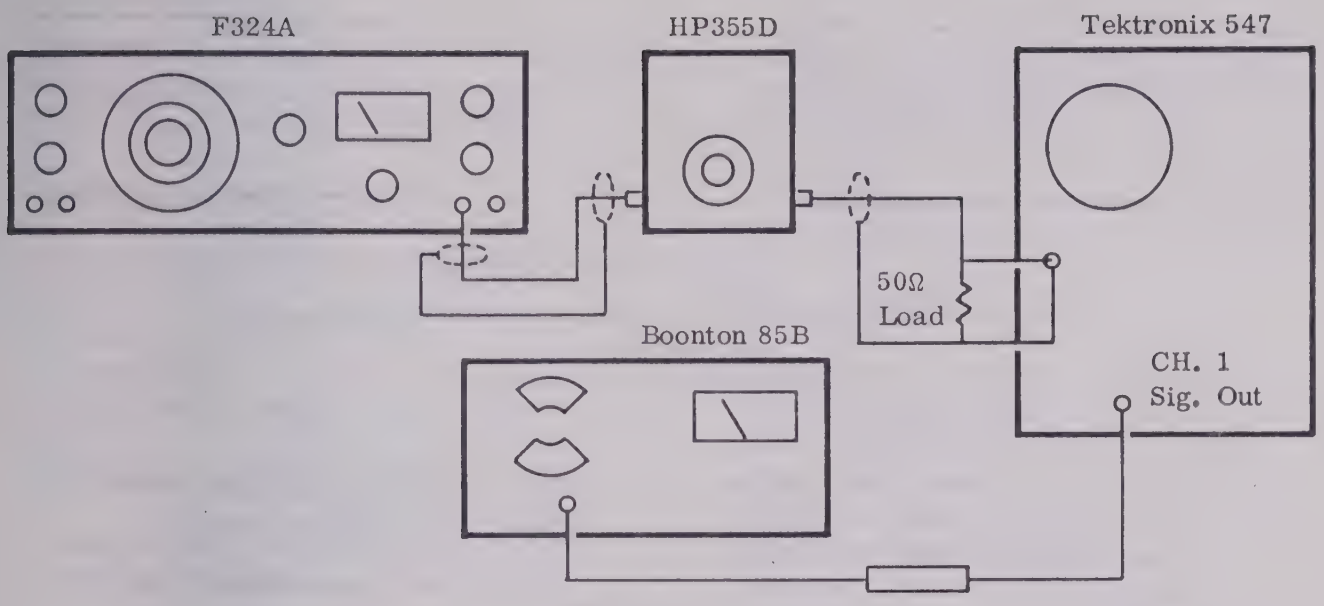


FIGURE 5-11

output in a 50Ω load.

b. Position controls as follows:

Power	OFF
Frequency Range	X10
Frequency Dial	1
Amplitude	Clockwise
Attenuator.	+20
Impedance	50Ω Output Connector
RMS/P-P Switch	RMS

c. Turn the Power Switch to the ON (Sine, Square) position.

d. Using the 333A, measure the distortion.

e. Observe that the distortion is less than 1%.

f. Position the Frequency Dial to 5.

g. Repeat Steps d and e.

h. Sequentially position the Range Switch to X100, X1K, X10K and X100K.

i. Measure the distortion on each range, and observe that the distortion is less than 1%.

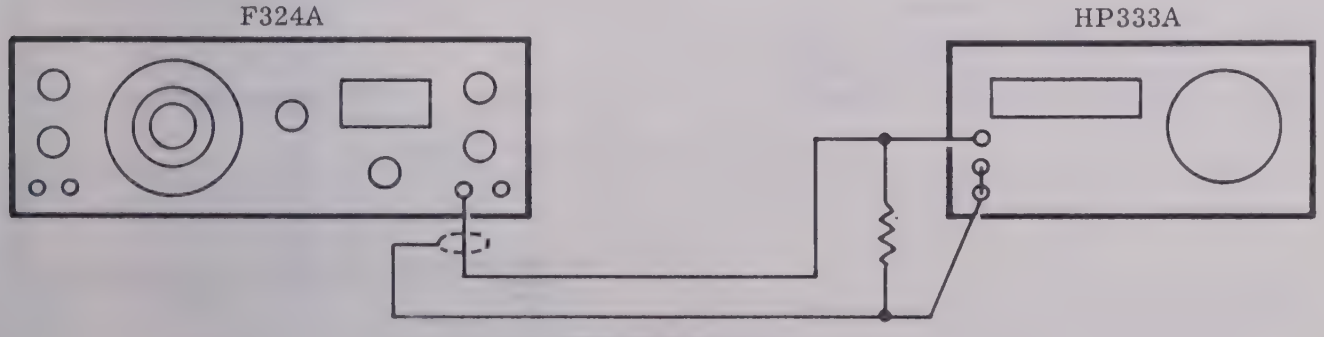


FIGURE 5-12

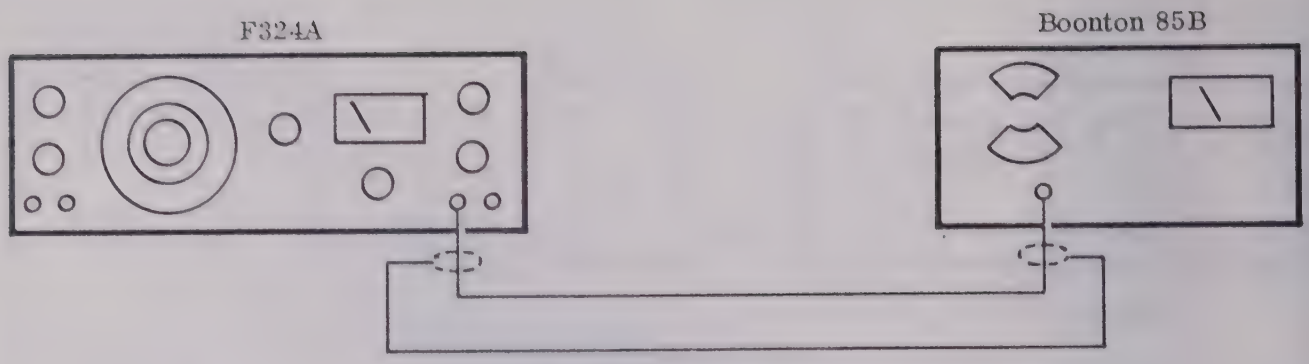


FIGURE 5-13

j. Interconnect equipment as shown in Figure 5-13, observing signal and ground connections carefully. Use the 50Ω Output Connector and DO NOT terminate the Output.

k. Position the Frequency Dial to 10. (1 MHz).

l. Using the Model 85B, measure the distortion.

m. Observe that the distortion is less than 1%.

n. Position the Range Switch to X1M.

o. Measure the distortion, and observe that the distortion is less than 4%.

p. Position the Frequency Dial to 6.

q. Measure the distortion, and observe that the distortion is less than 4%.

r. Position the Frequency Dial to 3.

s. Measure the distortion, and observe that the distortion is less than 2%.

t. Position the Frequency Dial to 1.

u. Measure the distortion, and observe that the distortion is less than 1%.

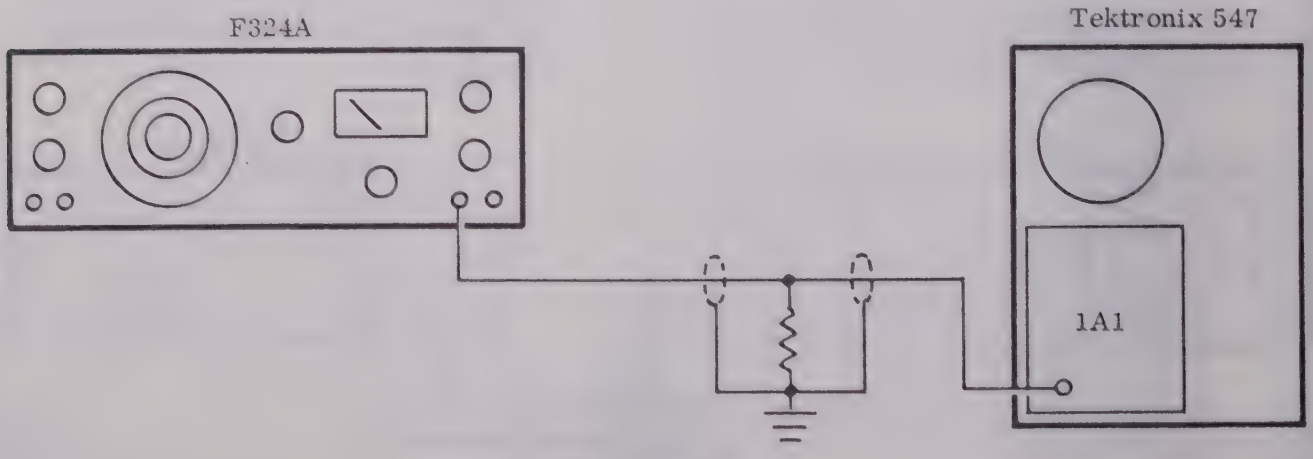


FIGURE 5-14

SQUARE WAVE
Models F323A and F324A

a. Interconnect equipment as shown in Figure 5-14, observing signal and ground connections carefully. (R1 = 50Ω).

b. Position controls as follows:

Power Switch	Sine, Square
Range	X100
Frequency Dial	5
Square Wave Amplitude Control	Mid-range

c. Measure the Rise and Fall Time.

d. Observe that the Rise and Fall Time is less than 10 nsec.

e. Adjust the sweep speed of the oscilloscope to get full horizontal deflection for one cycle of square wave.

f. Measure the Time Symmetry.

g. Observe that the Symmetry is 98% or better.

h. Position the Range Switch to X100K.

i. Repeat steps c thru g.

j. Position the Range Switch to X1M.

k. Repeat steps c thru g.

l. Observe that the Symmetry is 95% or better.

m. Position the Range Switch to X10K.

n. Increase the Square Wave Amplitude Control to 5V (Fully Clockwise).

o. Measure the Amplitude Symmetry.

p. Observe that the Amplitude Symmetry is within ±1% of maximum peak-to-peak output.

q. Observe that the Overshoot, Preshoot and Tilt do not exceed 5% of maximum peak-to-peak amplitude.

OUTPUT LEVEL METER

A. Normal Scale Accuracy:

a. Interconnect equipment as shown in Fig-5-9, observing signal and ground connections carefully. Terminate the output in a 50Ω load.

b. Position controls as follows:

Power	OFF
Frequency Range	X1K
Frequency Dial	10
Amplitude	Counter-clockwise
Attenuator	+20
Impedance	50Ω Output Connector
RMS/P-P Switch	RMS

c. Turn the Power Switch to the ON (Sine, Square) position.

d. Adjust the Amplitude Control for an indication on the Digital Multimeter of 3.000 volts.

e. Observe that the Output Level Meter reads 3 volts ±2% of full scale.

f. Repeat Steps d and e for levels of 2.000, 1.000, and 0.500 volts.

g. Observe that the Level Meter reads within ±2% of full scale in each case.

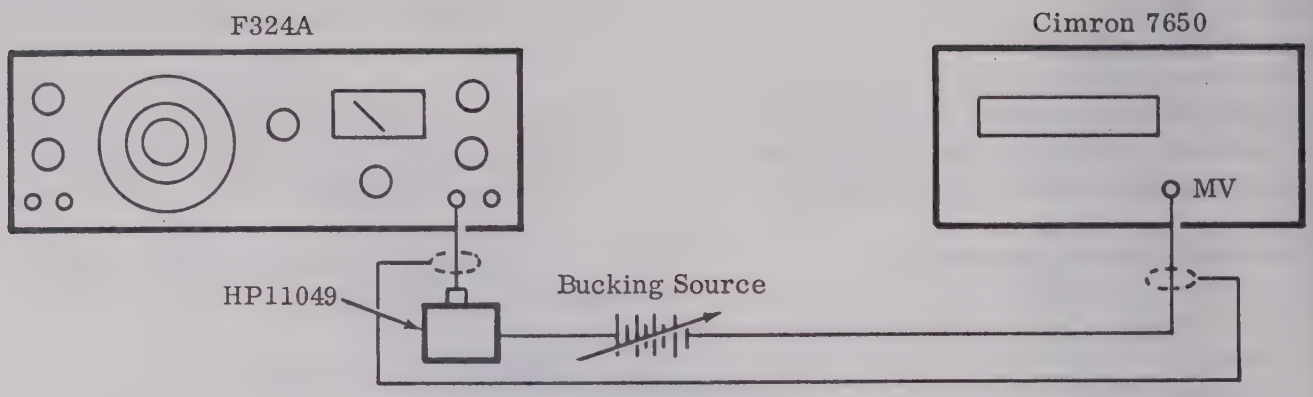


FIGURE 5-15

B. Expanded Scale Frequency Response: (F322A and F324A).

a. Interconnect equipment as shown in Figure 5-15, observing signal and ground connections carefully. DO NOT TERMINATE THE OUTPUT.

b. Position controls as follows:

Power	OFF
Frequency Range	X1K
Frequency Dial	10
Amplitude	Counter-clockwise
Attenuator	+20
Impedance	50 Output Connector
RMS/P-P Switch	RMS
Expand/Normal Switch	Normal

c. Turn the Power Switch to the ON position.

d. Adjust the Amplitude Control for an output level of 3 volts rms, as indicated on the Output Level Meter.

e. Position the Meter Switch to the Expand position.

f. Adjust the "Set Reference" and vernier Controls for an indication of 0 (zero) % on the top scale of the Output Level Meter.

g. Adjust the Bucking Source for an indication of 0.000 mv on the DVM.

h. Position the Frequency Dial to 5.

NOTE: Do not change the "Set Reference" and Vernier Controls.

i. Adjust the Amplitude Controls for an indication of 0% on the Output Level Meter.

j. Observe and record the reading on the DVM.

NOTE: On the 100mv range of the DVM, 12 digits (12μ volts) = 0.1% deviation).

k. Position the Frequency Dial to 10.

l. Repeat Steps i and j.

m. Position the Range Switch to X100K.

n. Repeat Steps i and j.

o. Position the Frequency Dial to 5.

p. Repeat Steps i and j.

q. Position the Frequency Dial to 1.

r. Repeat Steps i and j.

s. Position the Range Switch to X10K.

t. Repeat Steps i and j.

u. Position the Frequency Dial to 5.

v. Repeat Steps i and j.

w. Position the Frequency Dial to 10.

x. Repeat Steps i and j.

y. Position the Range Switch to X1K.

z. Repeat Steps i and j.

aa. Position the Frequency Dial to 5.

ab. Repeat Steps i and j.

ac. Position the Frequency Dial to 1.

ad. Repeat Steps i and j.

ae. Position the Range Switch to X100.

af. Repeat Steps i and j.

ag. Position the Frequency Dial to 5.

ah. Repeat Steps i and j.

ai. Position the Frequency Dial to 10.

aj. Repeat Steps i and j.

ak. Position the Range Switch to X10.

al. Repeat Steps i and j.

am. Position the Frequency Dial to 5.

an. Repeat Steps i and j.

ao. Position the Frequency Dial to 1.

ap. Repeat Steps i and j.

SECTION VI

RECOMMENDED SPARE PARTS

The following is a list of the recommended spare parts required to maintain a specific number of instruments at a satisfactory level of performance for one year in an isolated area.

PART DESCRIPTION	PART NUMBER	1 UNIT	5 UNITS	10 UNITS
Fuse, 1 4 Amp, Slo-blo	24-08001-0	2	4	6
Capacitor, Elect. 200μf 15V	21-57201-0	2	4	6
Capacitor, Elect. 10μf 25V	21-57202-0	2	4	6
Capacitor, Elect. 200μf 15V	21-57219-0	2	4	6
Capacitor, Tant, 10μf 20V	21-57800-0	2	4	6
Tunnel Diode, 1N3719	27-95003-0	2	4	6
Diode, SCE-2	27-95000-0	4	8	12
Diode, Zener, 1N5234	27-95251-0	2	4	6
Diode, Zener, 1N5244	27-95252-0	1	2	3
Diode, MS7000	27-95254-0	2	4	6
Diode, Zener, 1N5250 B	27-95256-0	1	2	3
Integrated Circuit, μA709C	25-08700-0	2	4	6
Integrated Circuit, μA741C	25-08713-0	1	2	3
Transistor, 2N2218	29-04500-0	1	2	3
Transistor, 2N3638	29-04503-0	1	2	3
Transistor, 2N3640	29-04504-0	1	2	3
Transistor, 2N4258	29-04507-0	2	4	6
Transistor, 2N4274	29-04508-0	2	4	6
Transistor, 2N4895	29-04510-0	1	2	3
Transistor, FET, 2N4360	29-04513-0	1	2	3
Transistor, RCA 40250	29-04515-0	1	2	3
Transistor, FET, RCA 40468	29-04516-0	2	4	6
Transistor, 2N5179	29-04517-0	2	4	6
Transistor, VCR2N	29-04517-0	1	2	3
Transistor, 2N4890	29-04524-0	1	2	3
Transistor, 2N5160	29-04525-0	2	4	6
Transistor, 2N3866	29-04522-0	2	4	6
Transistor, MPS6515	29-04538-0	2	4	6
Transistor, MPS6519	29-04539-0	2	4	6

LIST OF MANUFACTURERS
FEDERAL SUPPLY CODE TO NAME

FEDERAL SUPPLY CODE	MANUFACTURER	ADDRESS
00853	Sangamo Electric Company	Pickens, South Carolina
00121	Allen Bradley Company	Milwaukee, Wisconsin
01295	Texas Instruments, Inc.	Dallas, Texas
04062	Elmenco Products Company	New York, New York
04387	Dale Electronics, Inc.	Burbank, California
04713	Motorola Inc. Semiconductors Products Division	Phoenix, Arizona
07115	Corning Glass, Electronic Components	Bradford, Pennsylvania
11350	Penn Resistor Corporation	Langdale, Pennsylvania
12126	Kidco, Inc.	Medford, New Jersey
12406	Elpac, Inc.	Fullerton, California
14099	Semtech Corporation	Newbury Park, California
14655	Cornell-Dubilier Electric Corporation	Newark, New Jersey
15112	Electra Scientific Corporation	Fullerton, California
15818	Amelco Division, Teledyne Corporation	Mountain View, California
17227	Raytheon Company	Mountain View, California
17856	Silliconix	Sunnyvale, California
20574	Sterling Manufacturing Company	Sterling, Colorado
21845	Solitron Devices, Inc.	Riviera Beach, Florida
22259	Nytronics, Inc.	Berkeley Heights, New Jersey
27556	IMB	Santa Fe Springs, California
28584	Fairchild Camera & Instrument	Mountain View, California
29085	Data Royal Corporation	San Diego, California
38315	Honeywell Inc. Precision Meter Div.	Manchester, New Hampshire
44655	Ohmite Manufacturing Company	Skokie, Illinois
49671	Radio Corporation of America	New York, New York
56289	Sprague Electric Company	North Adams, Massachusetts
71002	Birnbach Radio Company	New York, New York
71450	CTS Corporation	Elkhart, Indiana
71590	Centralab	Milwaukee, Wisconsin
72982	Erie Technological Products	Erie, Pennsylvania
73490	Beckman Helipot Corportion	South Pasadena, California
75915	Littelfuse, Inc.	Des Plaines, Illinois
78488	Stackpole Carbon Company	St. Marys, Pennsylvania
80294	Bourns Laboratories	Riverside, California
81073	Grayhill, Inc.	La Grange, Illinois
82389	Switchcraft, Inc.	Chicago, Illinois
84171	Arco Electronics Company	Great Neck, New York
88140	Cutler-Hammer, Inc.	Lincoln, Illinois
*	Kemet	Granville, Illinois
*	Mallory Capacitor Company	Indianapolis, Indiana

*No Federal Supply Code number assigned.

AILTECH
A CUTLER-HAMMER COMPANY

WARRANTY

Except for tubes, crystals, semiconductors, fuses and batteries which carry no warranty, AILTECH, in connection with equipment sold, agrees to correct any defect in workmanship or material which may develop during the period of one year from the date of shipment under proper or normal use and not in excess of of the original manufacturer's life expectancy ratings, by its option to repair or to replace, F.O.B. point of shipment, the defective part or parts, and such correction shall constitute a fulfillment of all AILTECH liabilities in respect to said apparatus.

ACCOPRESS®

25170	YELLOW
25171	BLACK
25172	LIGHT BLUE
25173	DARK BLUE
25174	LIGHT GRAY
25175	LIGHT GREEN
25176	DARK GREEN
25177	TANGERINE
25178	RED
25179	EXECUTIVE RED

WITH WATER RESISTANT

PRESSTEX® COVERS

ACCO.

ACCO INTERNATIONAL INC.
CHICAGO, ILLINOIS 60619